CRANFIELD UNIVERSITY

Ahmed AYAD

An evaluation of small satellite technology transfer and capability-building in Algeria

Cranfield Defence and Security

PhD Thesis
Academic Year: 2017 - 2018

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ABSTRACT

The potential for satellite technology to make an essential contribution to socio-economic development has been recognised by the international community since the onset of space adventure in the late 1950s. Due to its complexity and the resources required, satellite technology development has always been the reserve of major powers. However, a new trend emerged in the 1990s towards developing smaller and cheaper satellites. It is driven by the spectacular development in information and communication technologies, advances in technology miniaturisation, rising performance of off-the-shelf components, and space sector globalisation. This trend has lowered barriers to entry for small developing countries. They have used the new mechanism of small satellite collaborative projects in order to transfer Earth observation small satellite technology from developed countries.

Like other developing countries, Algeria has leveraged this trend and engaged successively in three Earth observation small satellite collaborative projects with foreign companies in order to build small satellite capability. The purpose of this study is, thus, to evaluate whether Algeria has skilfully combined the technology acquired from abroad with local efforts to build effective and sustainable local small satellite capability.

Technological capability-building through technology transfer usually refers to the ability to reconcile two categories of factors: i) exogenous factors, external to the country's socio-economic environment, that condition the transfer of technology from abroad - these factors are traditionally gathered under the body of knowledge called 'technology transfer'; and ii) endogenous factors, relating to the local effort to effectively acquire and indigenise the transferred technology – these factors are traditionally gathered under the body of knowledge called 'technological capability-building'. Technological capability-building through technology transfer is also viewed as a learning process where knowledge is transferred from abroad and locally diffused.

The evaluation approach adopted in this study examines the small satellite capability-building programme from a knowledge-oriented perspective. Algeria's context is appraised by using the Innovation System analytical approach. The programme planning is evaluated by using the ‘strategic planning’ analytical approach. The programme implementation is evaluated by placing technological learning at the heart of the study. Two systemic models for the evaluation of knowledge flow from the transferor to the transferee, and then to its local environment, have been devised and tested. The knowledge-oriented perspective has been triangulated with perspectives stemming from the two traditional bodies of knowledge: technology transfer and technological capability-building. The evaluation has been comprehensive by taking into account factors across different levels of analysis: individual and team (micro level); organisation or firm (meso level); and national, sectoral and international (macro level). The evaluation has been performed through a mixed method research design.

The research findings indicate that the process of building small satellite technological capability in Algeria has provided mixed results, and the most concerning are at the macro level. Algeria has failed to establish a strong foothold between the nascent satellite development activities and a local supply chain. Moreover, at the meso level, Algeria has not established an effective learning organisation that can lead, synergistically and coherently, satellite development activities. Finally, at the micro level, Algeria has failed to align technology transfer mechanisms with satellite development objectives.

Based on these findings, the study highlights the need for clear strategies with prioritised objectives. It recommends elevating management capability-building as an absolute priority, and suggests the adoption of appropriate technology transfer mechanisms and a diversified projects portfolio.

Keywords:

Small satellite, Complex technology, Developing countries, Technology transfer, Technological capability-building.

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ACKNOWLEDGEMENTS

I first wish to express my heartfelt thanks to my supervisor, Professor Ron Matthews. It has been a joy and honour to work with him. His unique combination of rigour within a relaxed atmosphere, close supervision without restricting freedom of thought, and a strong presence which is barely felt, suited me and this research well. I thank him for supporting my ideas so consistently.

My gratitude goes to Dr Roger Darby, Dr Irfan Ansari and Dr Annie Maddison Warren, who were on my PhD Research Committee. They were completely supportive and provided constructive criticism. I am also grateful to Professor Mohammed Saad, Dr Thomas O'Brien and Dr Jonathan Painter for agreeing to be my examiners and for their painstaking efforts in going through my thesis.

I am particularly indebted to those that I have interviewed in my fieldwork for their in-put and responses. Their participation is at the heart of this thesis. My thanks go to the Centre for Defence Management and Leadership community, particularly, Kerry Iwaniszyn, Paula MacPhee, Thomas Hamilton-Baillie, Dr Teri McConville and Dr Iftikhar Zaidi for their kindness and support throughout my stay in the Centre. Not forgetting my friends Edith Wilkinson and Ivan Vitanov for the long discussions and their contributive opinions.

I would also like to record my gratitude to the Ministry of Defence, Algeria, for granting me the opportunity to undertake this research. I am particularly indebted to Major General Omar Farouk Zerhouni, Chairman of the Board of the Algerian Space Agency, for championing this study. My profound thanks also to the Algerian Space Agency community for their active participation and constant support.

Finally, this doctoral study would not have been possible without the tireless support of my family, their belief and unceasing love and patience through this journey.

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LIST OF ABBREVIATIONS

AC	Absorptive Capacity
AIT	Assembly, Integration and Test
Alsat	Algerian Satellite
AOCS	Attitude and Orbit Control System
AR	Acceptance Review
ASAL	Agence Spatiale Algérienne (Algerian Space Agency)
CAS	Centre des Applications Spatiales (Centre of Space Applications)
CDR	Critical Design Review
CDS	Centre de développement de Satellite (Centre of Satellite Development)
CDTA	Centre de Développement des Technologies Avancées (Centre for Development of Advanced Technologies)
CEST	Centre d'Exploitation des Systèmes de Télécommunications (Centre for Exploitation of Telecommunication Systems)
CNES	Centre National des Etudes Spatiales
CoPS	Complex Product Systems
COPUOS	Committee on the Peaceful Uses of Outer Space/United Nations
COTS	Commercial Off-The-Shelf
CRR	Commissioning Result Review
CTS	Centre des Techniques Spatiales (Centre of Space Techniques)
CubeSat	Cube Satellite
EADS	European Aeronautic Defence and Space
ECA	Entreprise de Construction Aéronautique (Aircraft construction company)
ECSS	European Cooperation for Space Standardisation
EDTAS	Ecole Doctorale des Technologies et Applications Spatiales (Doctoral School of Technology and Space Applications)

EGSE	Electrical Ground Support Equipment
ELR	End-of-life Review
ELT	Experiential Learning Theory
EO	Earth Observation
FBC	Faster, Better, Cheaper
FDI	Foreign Direct Investment
FRR	Flight Readiness Review
GDP	Gross Domestic Product
GEO	Geostationary Earth Orbit
GNI	Gross National Income
GNP	Gross National Product
ICT	Information and Communication Technologies
IMF	International Monetary Fund
INCOSE	International Council on Systems Engineering
Inty	Intensity of effort (provided during the learning process)
ISO	International Organization for Standardisation
ISRO	Indian Space Research Organisation
KARI	Korean Aerospace Research Institute
KHTT	Know-How Transfer and Training
KT	Knowledge Transferred
KVel	Knowledge Velocity
KVis	Knowledge Viscosity
LEM	Learning Evaluation Milestones
LEO	Low Earth Orbit
LRR	Launch Readiness Review
MCR	Mission Close-out Review
MDR	Mission Definition Review

MGSE	Mechanical Ground Support Equipment
NASA	National Aeronautics and Space Administration
NIC	Newly Industrialised Countries
OBC	Onboard Computer
ORR	Operational Readiness Review
PBS	Product Breakdown Structure
PDR	Preliminary Design Review
PK	Prior Knowledge
P.M.T.C	Performance Metrics related to Technological Capabilities
P.M.T.L	Performance Metrics related to Technological Learning
P.M.T.T	Performance Metrics related to Technology Transferred
PNR	Programmes Nationaux de Recherche (National Research Programmes)
PRR	Preliminary Requirements Review
QR	Qualification Review
R&D	Research & Development
SatReC	Satellite Technology Research Centre-Korea
SIA	Satellite Industry Association
SME	Small and Medium-sized Enterprises
SRR	System Requirements Review
SSTL	Surrey Satellite Technology Limited
S&T	Science and Technology
UN	United Nations
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organization
USA	United States of America
WB	World Bank

WBS	Work Breakdown Structure
WWII	Second World Two

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Chapter 1: Introduction

1.1 Making the case for the study

Technology transfer from developed to developing countries is seen as a catalyst for accelerating the technological capabilities of developing countries. Satellite technology, traditionally the reserve of major powers, was not so much concerned with this debate. However, a new international dynamic has emerged over the last two decades; namely, the rise of a new international industrial transfer mechanism called satellite collaborative projects, allowing small countries with a relatively constrained budget to access small satellite technology and start building up their own small satellite capabilities.

Since the early 2000s, Algeria has used this mechanism in order to build up its small satellite capabilities. The question that currently arises is whether Algeria has skilfully combined the technology acquired from abroad with local efforts so as to build effective and sustainable local small satellite capabilities.

The following sections of this opening chapter shed light on space technology potential, providing an overview of its evolution and the international context fostering its adoption. It will be seen that the new trend towards small satellites lowers barriers to entry for small developing countries. First, the mechanism used by the latter to acquire technology is briefly presented. Then, foundational considerations underpinning the evaluation of small satellite capability-building in Algeria are explained. This leads to the formulation of the study aim, and an articulation of the study's contribution to knowledge. A conceptual model is then provided illustrating the building blocks of this study. Finally, the structure of the thesis is presented.

1.2 Space technology potential and its adoption in developing countries

Mankind has always gazed at space with fascination. Curiosity, along with the desire to push forth the boundaries of the known world has led to the progressive conquest of space. The latter was formally begun in 1957 with the launch of the first Earth-orbiting satellite. Since then many important achievements have been realised that use space for the well-being of humanity and its development. None of these achievements would have been possible without the outstanding development of space technologies or, indeed, 'terrestrial' technologies that were upgraded and adapted to meet the requirements of space. This raises the question as to the contribution these technologies have made, and whether they have fostered progress, particularly in developing countries.

1.2.1 Technology: a key driving force in development

The importance of technology in supporting and sustaining socio-economic development, in both developed and developing countries, is recognised and has been extensively documented.[1] Technology is held to be the main lever for economic development. Scholarly works reveal that technological progress is a dominant factor in long-term economic growth[2] and the most important factor affecting economic growth rate.[3] Several studies stress the role of technology in sustaining more than 50 percent of long-term economic growth in industrial countries.[4] Research on the East Asian countries shows that productivity growth, which is the best proxy for technology progress, accounts for as much as 30 percent of gross domestic product growth.[5]

Technology also plays a prevailing role in human development in the current era. Its strengths lie in information, knowledge and ICT development.[6] Indeed, this development has led to a revolutionary technological progress that has brought major changes in education, work patterns, employment and job markets, as well as quality of life, through social behaviour change, including increased personal empowerment, self-reliance and freedom.[7]

Regarding the role of technology in achieving sustainable development, it is worth recalling that environmental impact is affected by three factors: population growth, consumption, and technology used to transform resources into consumable products.[8] Governments are currently unable to reduce population growth and face difficulties in changing consumption models. Consequently, technology is left as the major factor to reckon with in order to achieve sustainable development.[9]

Recognising the vital role of technology, developing countries have continuously engaged over roughly the last sixty years (mainly after WWII) in a quest to build technological capability and move from poverty to prosperity. There are three non-mutually exclusive options these countries face in developing technological capability:[10] (i) acquiring technology from abroad, (ii) improving the locally existing technology, and (iii) starting from scratch by using R&D and production experience to develop new indigenous technology. However, in the context of the early developmental stage of these countries, technology acquired or transferred from overseas is likely to be the major source of technology.[11] This is particularly fostered by the openness in international technology transfer relationships during recent decades. Fredland[12] points out that since 1989, international technology transfer has been "intentional… apolitical or moderately political, global economy compatible, integrated and supported through global economy".[13] On the other hand, he recalls that it was "intentional… political or highly political"[14] from 1945 to 1989, and "inadvertent, incidental… nonpolitical or apolitical"[15] during the 19th century through to 1945.

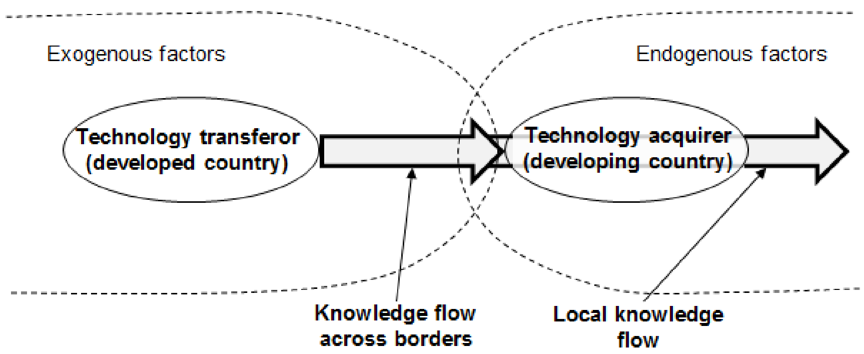
A noteworthy range of technologies that contribute significantly in building developed country capabilities is already available in the international market or public domain. However, these technologies are not easily accessible because of their cost or the lack of appropriate knowledge for their acquisition.[16] In addition, technology is a kind of knowledge and is thus a cross-cutting concept and not a product. Acquiring it is therefore difficult.[17]

Moreover, transferring technology to developing countries goes beyond its mere acquisition from abroad. It aims to build nation's local technological capabilities.[18] This dual objective refers to the ability to reconcile exogenous factors, external to the country's socio-economic environment, with endogenous and local factors.

Indeed, a review of developing country experiences makes it clear that for a successful and sustainable building of technological capabilities, the acquisition of technology from abroad should be accompanied by an indigenous assimilation effort.[19] In general, the latter is oriented towards fully utilising imported technologies, and then, through indigenous adaptation and improvement, a new technology is developed.[20]

From a knowledge-based stance,[21] the whole process can be looked at as a technological learning phenomenon in which technology (as knowledge) flows from foreign to local actors (Figure 1-1). Knowledge is conveyed across borders through an international transfer effort, involving factors exogenous to the country. It is then locally disseminated through a local technological capability-building effort, involving endogenous factors.

Figure 1-1: Knowledge flow from foreign to local actors



Source: Author.

Acquisition and progressive mastering of technology is considered to be one of the key driving forces underpinning the spectacular economic take-off and development of the so-called "first tier" Asian Newly Industrialised Countries.[22] However, technology mastering and indigenisation has not always been successful. Several developing countries have engaged in this quest but with limited impact on their local capabilities.[23] The fact remains that success (or failure) stories of technological development vary from one country to another, depending on industrial (or sectoral), technological and market conditions.

1.2.2 Space technology potential

Following the launch of the first Earth-orbiting satellites in the late 1950s, the potential for space technology[24] along with its applications to make essential contributions to economic and social development was quickly recognised by the international community. Space activities expanded quickly in the following decades and demonstrated their usefulness in everyday life. Space activities have significantly impacted the human condition, environmental protection, economic progress, institutions and policy.[25] Space investment also demonstrates tremendous potential for deeper impact in the future. Wood & Weigel[26] synthesise the three ways where space contributes to global society: space provides infrastructure, information and inspiration.

Infrastructure refers to local, regional and global infrastructures (e.g. satellites, ground segment, and user terminals) that support human activity. Space also provides information that reduces uncertainty,[27] creating tangible benefits for individuals, governments and businesses. Moreover, "the unique environment of space often inspires creative engineering approaches and innovative solutions".[28]

In the context of developing countries, the contribution of space technology in multi-sectoral development is undeniable.[29] Better still, beyond the physical and tangible sense of fulfilling developmental needs, space promotes "the sense of national pride and confidence amongst [developing countries'] citizens".[30] Indeed, the vast majority of developing countries emerging from colonialism face a pessimistic perception of themselves.[31] Promoting space-related technological challenges creates a sense of national pride and instils confidence amongst developing country populations. Space has the ability to capture the imagination of the public. Any space achievement will spread confidence amongst citizens, foster a spirit of national unity, and promote a desire to take up further challenges.[32] Two outstanding examples of changing national self-perception through challenging space programmes are offered by China and India. Both countries have achieved exceptional development in space technology within the past five decades and have demonstrated that, even within a challenging developing country context, perceptions and a community's confidence in its own abilities can change.

Many developing countries[33] have entered into space activities facing various circumstances, harbouring differing ambitions, and achieving different results. However, they have all pursued similar motivations: socio-economic development along with political, security and sovereignty objectives. Regardless of circumstances and motivations, foreign space technology and international cooperation are catalysts for building local capability.

Space technology programmes development and categorisation

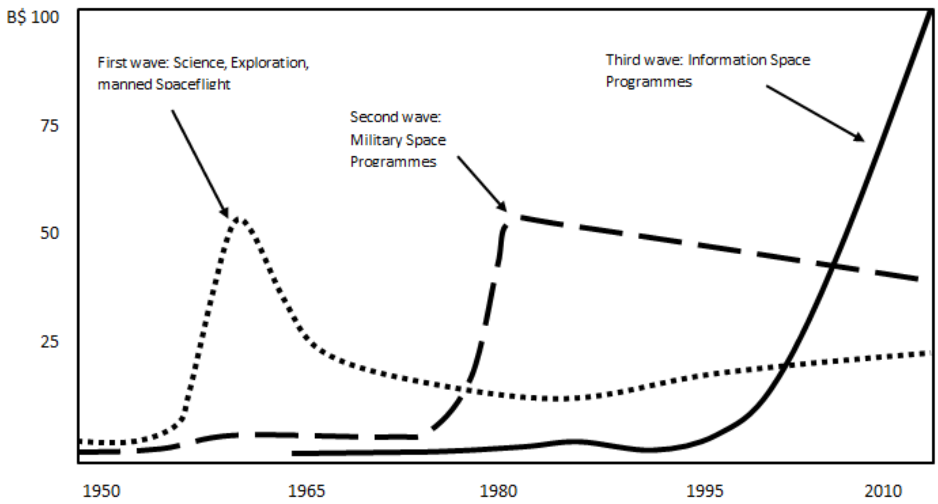
Space activities are often divided into two major categories: i) space applications, including remote sensing (or Earth observation) systems, satellite communications and navigation, satellite meteorology and atmospheric sciences, and ii) basic space science, including astronomy and astrophysics, solar-terrestrial interactions, planetary and atmospheric studies and exobiology. Both categories are based on space technology utilisation.

The most common and significant contribution to development lies in space applications stemming from services provided by satellites.[34] Most of these services are categorised according to the satellite mission, such as: i) remote sensing (or Earth observation) satellites used for collecting information about the Earth and objects on it, ii) communication satellites that enable radio, television and telephone transmissions, and (iii) positioning satellites that determine object positioning on the ground and in space surrounding the Earth.

Dupas[35] explains that space development occurred in three waves (Figure 1-2). The first was mainly led by developments in science exploration and manned space flight in the 1960s. It resulted from the space race between the United States and the former Soviet Union. Space activities during this period were almost exclusively funded by governments. The second wave in the 1970s was led by developments in military space programmes. This period is characterised by the use of space for defence and security purposes. Governments were still the main financier of space activities during this period. However, the private sector developed expertise particularly in communication satellites.

The third wave was led by the 1990's development in information space programmes, and is still ongoing. This wave has had a considerable effect on space development. It is driven by the revolution in Information and Communication Technologies. It is also driven by the tendency towards a globalised space sector, characterised by international collaboration and the growing role of private sector (or commercial) activities.[36]

Figure 1-2: Waves of space development



Source: adapted from Dupas, A., 1995. In Search of Waves of Space Development. Presentation to Space Policy Institute, George Washington University, USA. Second reference in: Waswa, P.M.B, Juma, C., 2012. Establishing a space sector for sustainable development in Kenya. International Journal of Technology and Globalisation 6(1-2), pp.152-169.

The third wave is characterised by the growth of satellite activities, or services provided by satellites (e.g. satellite TV, broadband, communications, and Earth observation services).[37] The upstream segment (i.e. satellite manufacturing, ground equipment and launch industry) still participates in this growth. For this reason, the space industry is defined as "the economic sector providing goods and services related to space".[38]

Looked at differently, the space industry encompasses two major components: the satellite and non-satellite industries.[39] Because it is difficult to identify what the non-satellite industry comprises, there is a blanket focus on satellite-related activities when it comes to the space sector. Consequently, the common practice is to focus on the satellite industry and to use interchangeably the terms satellite industry and space industry.[40]

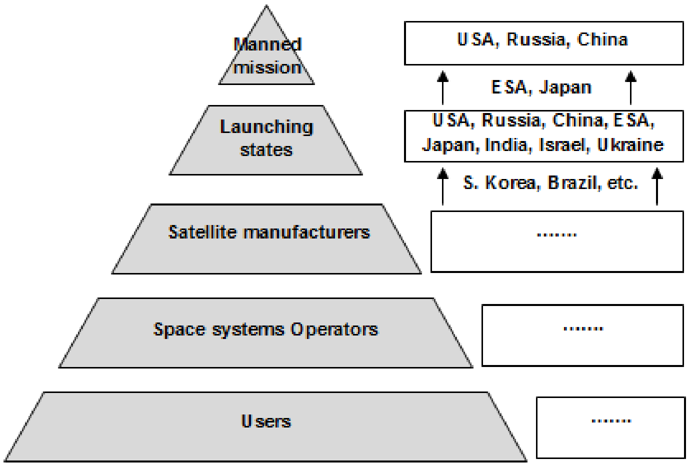
Technological advances in terms of miniaturisation and performance of off-the-shelf components have significantly contributed to the emergence of a trend towards building smaller and cheaper spacecraft. This trend brought a concomitant reduction in domestic space budgets and gave rise to a new 'small' satellite business model. Consequently, there is growing interest in space on the part of budget-limited developing countries. The trend has opened up the exclusive ranks of spacefaring nations to new entrant states (e.g. Algeria, Egypt, Nigeria, Turkey, Chile, Peru, Venezuela, United Arab Emirates, Malaysia, Thailand, and Vietnam), which have engaged in building satellite technology capability through acquisition of small satellites via technology transfer programmes.

1.2.3 Space technology capability-building

Capability-building has often been explained through a set of achievements spread out over a space technology sophistication continuum. Building space capability corresponds to progressing from one step to another. The steps are ranked according to technical complexity, cost and managerial autonomy. They also reflect the historical strategies of developed and developing countries engaged in space technology. Two major frameworks illustrate this hierarchical order: firstly, Leloglu & Kocaoglan's[41] one-dimensional pyramidal structure, and, secondly, Wood & Weigel's[42] space technology ladder.

In the first framework (Figure 1-3), countries can be hierarchically grouped according to their level of mastery of space technology. For example, the base of the pyramid is large because all countries are 'users' of space technology. The apex of the pyramid is narrow, and limited to countries that have successfully conducted manned space missions.

Figure 1-3: The space technology pyramid



Source: Leloglu, U.M., Kocaoglan, E., 2008. Establishing space industry in developing countries: Opportunities and difficulties. Advances in Space Research 42, 1879–1886

In the second framework (Table 1-1), countries are ranked according to space technological complexity and managerial autonomy. Thus, in addition to the organisational aspect represented mainly by the first step 'establishing a national space agency', the ladder framework is built by using additional major steps and is more detailed in terms of technological achievement. The second step consists of owning and operating a satellite in low Earth orbit, corresponding generally to a remote sensing satellite (or Earth observation). The next step is that of owning and operating a satellite in geostationary orbit corresponding generally to a communication satellite. The capacity to launch satellites is the ultimate step.

Table 1-1: The space technology ladder

Categories	Sub-categories or Milestones	
Launching satellites	13	Satellite to GEO (Geostationary Earth Orbit)
	12	Satellite to LEO (Low Earth orbit)
Owning and operating a satellite in geostationary orbit	11	Build Locally
	10	Build through Mutual International Collaboration
	9	Build Locally with Outside Assistance
	8	Procure
Owning and operating a satellite in low Earth orbit	7	Build Locally
	6	Build Through Mutual International Collaboration
	5	Build Locally with Outside Assistance
	4	Build with Support in Partner's Facility
	3	Procure with Training Services
Establishing national Space Agency	2	Establish Current Agency
	1	Establish First National Space Office

Source: Wood, D., Weigel, A., 2012. Charting the evolution of satellite programs in developing countries – The space Technology Ladder. Space Policy 28, 15-24.

The above two frameworks reflect the general debate on space capability-building in both developed and developing countries. They identify major space technology development milestones at country level, whether they be developed or developing. This hierarchy of 'macro' steps informs on the major milestones for building small satellite capability. However, the level of aggregation remains insufficient and inadequate for capturing the finer granularity and peculiarities of small satellite capability-building, particularly in the specific context of developing countries, such as technological autonomy. Moreover, the frameworks are unclear as to the share of technological acquisition from abroad (imports) and the degree of technological indigenisation (technology locally generated).

The same 'macro' perspective is reflective of the commonly adopted approach when evaluating space technology capability-building. Evaluation is based on 'instrumental' use of 'macro' outcomes and achievements, and says little about the finer details of the phenomenon.

1.3 New dynamic of small satellite technology transfer to developing countries

As mentioned earlier, small satellite technology transfer has been facilitated by a wave of information and communication technologies, technological advances in terms of miniaturisation, and performance of the off-the-shelf components. This wave is inherently 'Global', and has been boosted by extensive international collaboration, with greater involvement of 'small' developing countries.

This dynamic, or the new way of manufacturing small satellites, was largely popularised by a University of Surrey-owned spin-off company, Surrey Satellite Technology Limited (SSTL).[43] As a pioneer in small satellite technology, SSTL exploited the opportunities arising from the profound transformation of the space industry. It developed a business model in the 1990s based on a unique Know-How Transfer and Training (KHTT) programme, along with Earth observation satellite manufacture.[44] Within this programme, a combination of academic and hands-on technical training was provided to engineers and scientists from countries wishing to take the first steps into space on an affordable budget. By working together as a team with SSTL engineers to build a satellite, developing states were able to start working on complex technological systems, generating the diverse skills required to design, build, launch and operate a satellite once in orbit.[45]

SSTL's business model, called the collaborative satellite project, has subsequently been adopted by numerous companies and space agencies throughout the world. After more than two decades of small satellite development and commercialisation, collaborative small satellite projects are perceived as the most common mechanism of international satellite technology transfer directed towards small developing countries. These countries typically have limited budgets and little or no experience in space technology. Sophisticated forms or variants of this mechanism have been adopted by developing countries in Africa, Asia and Latin America, with the common aim of achieving a higher level of independence in satellite capability.

1.4 Developing small satellite capability in Algeria

Algeria's development effectively started in the late 1960s following a trial and maturation period that began in 1962 just after Independence. Algeria first adopted a planned economy model from the late 1960s to the late 1980s.[46] The model was heavily oil-dependent and failed in producing the desired results. A market economy was then adopted in the late 1980s.[47] Since then, ineffective measures have been taken to promote transition towards a new economic model. Algerian development trajectory has been characterised by incorrect choices, inconsistencies, interruptions, and short-sighted perspectives. Consequently, Algeria is still thought of as being in economic transition, and continues to be heavily oil-dependent.[48]

Within the 1990's transitional phase, the idea of building small satellite capabilities in Algeria emerged. The strategic value of space technology, and its applications, has progressively increased. The need for developing national space activities coincided with an international context favourable to technology transfer.

Algeria seized the opportunity and engaged successively in three Earth observation small satellite collaborative projects with foreign companies. The first was the Alsat-1 project with SSTL/UK in 2001.[49] The second was the Alsat-2 project with Airbus Defence and Space (previously EADS-Astrium)/France in 2005. This project comprised the development of two identical satellites: Alsat-2A in 2005 and Alsat-2B in 2012.[50] The third was the Alsat-1B project with SSTL/UK in 2014.[51]

Given Algeria's limited experience in satellite technology, these collaborative projects were used to take the first steps into satellite manufacturing through technology transfer.[52] They were also used as the backbone for devising a broader national space programme, covering both space technology (or satellite industry) and space applications, with the aim of achieving a higher level of independence.[53]

This undertaking has not always been viewed favourably in Algeria, and even in other 'small' developing countries. Some analysts[54] consider that due to their limited capabilities, developing countries would benefit more from a focused effort on space applications rather than venturing into satellite technology capability-building (or manufacturing).

Multiple studies[55] relating to other industries in developing countries show that achieving higher levels of technological independence through international technological transfer is a complex task. It depends upon diverse factors, notably the host country's technological capability.

Despite the popularity of small satellite collaborative projects, there is a lack of hindsight and objectivity as to their effectiveness in building sustainable satellite technological capability in developing countries. This argues for a cautious stance when using collaborative projects as a technology transfer mechanism, and, accordingly, requires a deeper evaluation.

Technological capability-building through technology transfer has a literature base that is widely influenced by a mono-dimensional economic perspective. Emphasis is usually placed on economic goals such as the transferred technology's impact on productivity, or on the cost-benefit of production.[56] This perspective is restrictive when dealing with Earth observation small satellite technology, because the direct and immediate economic potential is not proven (as discussed in chapter 3).

An exclusive economic perspective is also inappropriate for studying technology transfer in the Algerian context. Algeria is currently stuck in a long-lasting transitional period in which economic choices are uncertain (as discussed in chapter 6). However, the body of knowledge on technology transfer stems essentially from market economy environments. Analyses conducted on the basis of this solely economically oriented body of knowledge might be biased when it comes to Algeria's economic environment. The uncertainty makes it difficult to build a foothold between the studied satellite capability-building programme and its economic environment.

For these reasons, a knowledge-oriented perspective is central to this study.[57] This perspective reflects the "engineering" point of view, not least because the author is an engineer. Importantly, engineers consider technology transfer as knowledge transfer.[58]

For the purpose of formulating the study aim, these introductory comments have sought to make the case for an evaluation of small satellite capability-building in Algeria. The evaluation is knowledge-centred, grounded in today's context of knowledge-based societies and knowledge-intensive industries (e.g. satellite technology).

1.5 Study Aim

The purpose of this study is to evaluate small satellite capability-building in Algeria.

1.5.1 Enabling objectives

1. Review of the foundational concepts of technological learning, technological capability-building, technology transfer and innovation systems in developing countries.
2. Analysis of small satellite technology: its peculiarities and the process of acquisition in developing countries.
3. Definition of the evaluation metrics.
4. Appraisal of Algeria's developmental and technological context.
5. Appraisal of small satellite capability-building programme planning.
6. Empirical analysis of small satellite technological learning in Algeria.
7. Empirical analysis of small satellite technology transfer in Algeria through collaborative projects.
8. Empirical analysis of indigenous development of Algerian small satellite capability.

1.6 Study Value

This thesis contributes to the established but still relevant debate on managing technology in developing countries. To paraphrase Drucker, "there are no 'underdeveloped' countries, there are only 'undermanaged' ones".[59] This is reflective of how essential it is to study managerial questions in developing countries. Like other sectors in Algeria, the space sector is truly representative of the challenges such countries face. Management of space technology within Algeria has never been studied, despite the multiple "technical" endeavours undertaken by the space leading organisation over the last two decades. Therefore, the present study attempts to provide knowledge that enriches the literature on space technology management in Algeria and developing countries in general. This is particularly relevant, given the growing international interest in space.[60]

The first principal contribution of this research derives from empirical evaluation and deep insights into small satellite capability-building in Algeria's nascent space programme. One of the strategic objectives of the latter is the development of industrial capabilities. Therefore, Algerian policymakers will gain appreciation on whether their developmental model is promoting effective industrialisation through generation of local value. Moreover, the Algerian space programme covers a planning period of 15 years (2006-2020), so it is timely to explore the programme’s progress.

The second principal contribution of this research lies in understanding better the relatively new phenomenon of building small satellite capability through the mechanism of collaborative projects. It relates more to the nature of relationships between developing and developed countries regarding technology transfer. Indeed, the satellite industry is a knowledge-intensive industry.[61] Developing countries intend to build, eventually, local technological capabilities from the technology transferred through collaborative projects. On the other hand, developed countries, as suppliers of technology, recognise that in a globalising world, their knowledge base provides the major comparative advantage. However, maintaining it requires protectionism. Reconciling those two goals is challenging. This research can aid in understanding some aspects of the contemporary knowledge-intensive relationships between developed and developing countries.

The third contribution of the study lies in its evaluation framework. In technological capability-building through technology transfer, knowledge flows from the transferor to the transferee, and then to its local environment (Figure 1-1). In order to evaluate the knowledge flow for the particular case of small satellite technology in Algeria, two systemic models, called ‘knowledge flow model’ and ‘experiential learning model’, have been devised and tested. These two models show conceptual potential for adaptation to knowledge flow (or learning) evaluation in further studies involving other industries with similar contexts.

1.7 Conceptual model

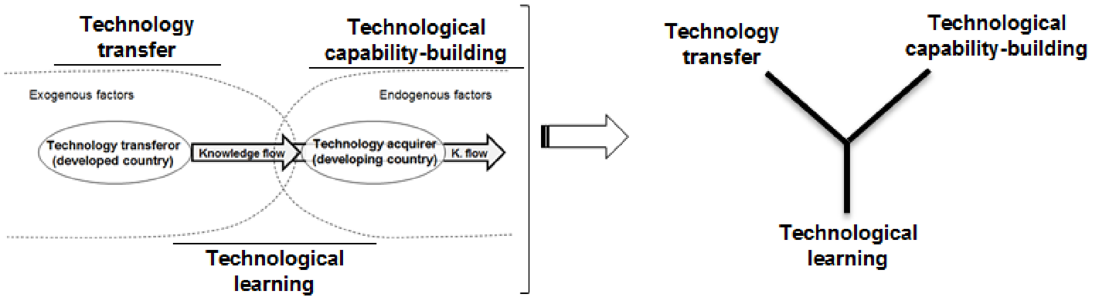
A conceptual model is a construct representing the “concepts, assumptions, expectations, beliefs, and theories that support and inform [the] research”.[62] It “explains, either graphically or in narrative form, the main things to be studied—the key factors, concepts, or variables—and the presumed relationships among them”.[63] The conceptual model assists the researcher in conducting the research and adds clarity for the reader.[64] It provides an overview of the intended research. Ideally, it connects all aspects, including the research aim, literature review, research methodology and analysis.[65] The model stems essentially from the literature review, where theories and concepts underpinning the study are identified.[66]

The rationale behind the conceptual model for this study (Figure 1-5) derives firstly from the meaning of the programme evaluation. The evaluation refers to “the systemic collection of information about the activities, characteristics and outcomes of programs to make judgments about the program, improve program effectiveness, and/or inform decisions about future programming”.[67] The evaluation aims to provide insights into the programme’s major phases: planning and implementation.[68]

Planning evaluation aims at examining whether the plan clearly connects the ‘mission’ to the ‘vision’.[69] The evaluation assesses whether the plan is complete, realistic, integrated (elements mutually supported) and balanced (resources, objectives).[70] The evaluation of Algeria’s small satellite capability-building programme is conducted from a ‘strategic planning’ perspective.[71] The latter offers a comprehensive approach which addresses relationships between strategic, intermediate, and operational levels, and encompasses numerous frameworks and models enabling the evaluation.[72]

Implementation evaluation determines whether programme activities have been properly implemented and producing the intended effect.[73] As illustrated in Figure 1-4 and detailed in chapter 2, the process of technological capability-building through technology transfer can be looked at, and then evaluated, from a triple perspective: (i) evaluation of the international transfer by focusing on the exogenous factors (technology transfer in Figure 1-4); (ii) evaluation of the locally-built capability by focusing on the endogenous factors (technological capability-building in Figure 1-4); and (iii) evaluation of the knowledge that flows from the transferor to transferee, and is then locally diffused (technological learning in Figure 1-4).

Figure 1-4: Triple perspective approach



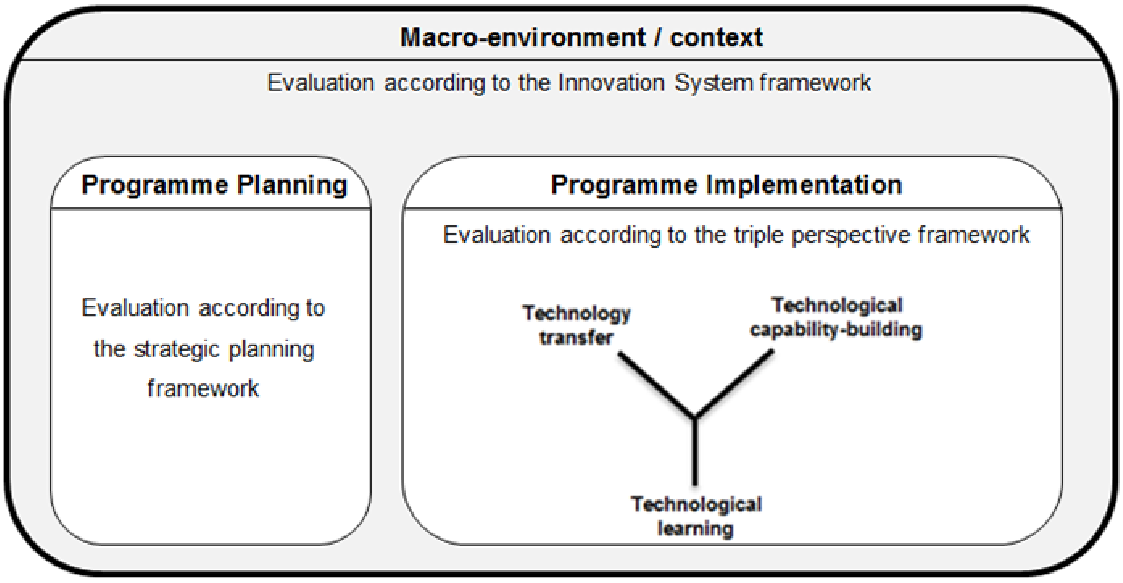
Source: Author

The literature reviewed in this thesis (chapters 2 and 3) reveals that technological capability-building through technology transfer involves a multitude of factors that can be categorised at individual and team level (micro level), organisation level (meso level), and sectoral, national and international level (macro level). Accordingly, any attempt at a comprehensive evaluation should be performed at all levels (micro, meso, and macro).

In addition, comprehensively evaluating a programme is not only about understanding its immediate activities, characteristics, and outcomes; it is also concerned with the comprehension of the setting in which it is undertaken as well as the wider environment (macro considerations). The programme is both affected by its context and attempts to influence this context. The embedment of the programme into its environment needs to be appraised if a comprehensive evaluation is to be achieved. However, the literature in chapters 2 and 3 reveals that the macro level is not sufficiently covered by the above-mentioned analytical perspective (or bodies of knowledge). Thus, the Innovation System approach is adopted for further analysis of the macro-environment.

Accordingly, the conceptual model in Figure 1-5 illustrates the building blocks of Algeria's small satellite capability-building evaluation. The starting point is the appraisal of Algeria's developmental and technological context, highlighting the macro considerations surrounding the small satellite capability-building programme. In a second stage, the study evaluates the planning from a strategic planning perspective. Finally, the study collates and analyses measurements across the implementation process.

Figure 1-5: Conceptual model: evaluation building blocks



Source: Author

1.8 Study structure

Beyond this introductory chapter, the study comprises seven further chapters. Chapter 2 provides a critical review of the literature on technological capability-building through international technology transfer in developing countries. Discussion is conducted from a knowledge-oriented perspective, where the literature on technological learning is reviewed. The latter perspective is enriched (triangulated) by perspectives from the traditional literature on technological capability-building and technology transfer in developing countries.[74] A knowledge-oriented perspective is also adopted to review literature on the environment by using the Innovation System analytical approach. Chapter 2 reveals the complexity of designing 'standard' measurements, and therefore underlines the need for a one-off approach that suits small satellite capability-building.

Chapter 3 reviews small satellite peculiarities and small satellite technology adoption in developing countries. It provides insights into the philosophy underpinning the complexity of small satellite development. The discussion identifies managerial factors required for successful development and categorises those factors according to levels of analysis (macro, meso and micro). This chapter reviews the mechanism of collaborative projects used for small satellite technology transfer. It also provides insights on selected relevant experiences (South Korea and India) in developing satellite capabilities.

Chapter 4 draws on the literature discussed in the previous two chapters and proposes the evaluation framework to be used in this study. A global framework is formed by three categories of evaluation metrics, covering three levels of analysis (macro, meso and micro). The knowledge perspective is at the heart of this study, and chapter 4 presents two systemic evaluation models as part of the global framework. They both encompass metrics related to knowledge flow, from knowledge conveyance (transferor to transferee) to its local diffusion (in developing countries).

Implementation of the evaluation framework requires empirical data. Chapter 5 positions the research and delineates the hierarchy of philosophical and methodological choices that led to the mixed design used in the study. Research quality considerations are highlighted throughout the chapter.

The analysis and findings from the evaluation of Algeria's small satellite capability-building programme are synthesised across chapters 6 and 7. Chapter 6 appraises the contextual backdrop of Algeria's technological development from an Innovation System perspective, and then traces and evaluates the planning of the small satellite capability-building programme from a strategic planning perspective. Chapter 7 deepens the evaluation by examining, systemically, the capability-building implementation process at macro, meso, and micro levels. It critically analyses the process according to three categories of evaluation metrics (technological learning, locally built technological capabilities, and the transferred technology).

Finally, chapter 8 concludes that, at the macro level, Algeria has failed in establishing a strong foothold between satellite development activities and the national environment. Actions at the meso level (organisations) are inconsistent, fragmented, and unbalanced. Actions at the micro level are not aligned with the defined objectives. Accordingly, a set of recommendations is offered towards crafting a more effective model for small satellite capability-building in Algeria.

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Chapter 2: Technology adoption in developing countries

Algeria uses foreign technology transfer as a catalyst towards building its own small satellite capabilities. Evaluating such an endeavour requires reviewing the literature on the general phenomenon of technology adoption in developing countries. In particular, the literature on how technological capabilities are built through international technology transfer.

As illustrated in Figure 2-1, the present chapter starts by recalling the role of technology in development (section 2.1), highlighting two concepts that are fundamental to understanding technology adoption in developing countries. The first is that technological development in developing countries involves exogenous factors linked to technology transferred from abroad, as well as endogenous factors associated with local technological capabilities.

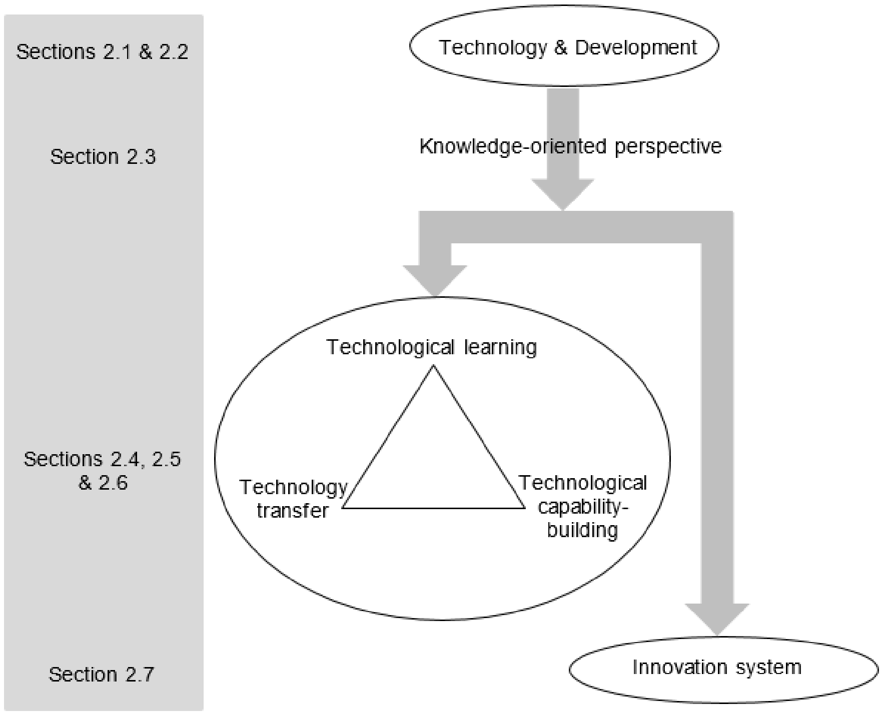
The second fundamental concept is that technology is knowledge which is conveyed across borders (international technology transfer) and disseminated internally (local technological capability-building). Hence the centrality of the knowledge-oriented perspective in this thesis (section 2.3).

Three bodies of knowledge are then reviewed. The literature on technological learning, which is at the heart of the present thesis, is covered in section 2.4. The approach is 'triangulated'[1] by a review of the relevant literature on technological capability-building and technology transfer (sections 2.5 and 2.6). This review reveals that learning technology (or building technological-capabilities through technology transfer) is affected by a multitude of factors. These factors can be categorised as being operative at individual and team levels (micro level), organisational and firm levels (meso level), and within the national, sectoral and international environment (macro level).

The review also reveals that the macro level is not addressed sufficiently well by the three above-mentioned bodies of knowledge. Thus, a knowledge-oriented perspective is adopted for further analysis of the macro-environment. The Innovation System analytical approach is then reviewed in section 2.7.

Finally, a critical appraisal of the literature in section 2.8 sheds light on the gaps that need to be filled in order to develop an appropriate approach for evaluating satellite capability-building in Algeria.

Figure 2-1: Chapter 2 structure



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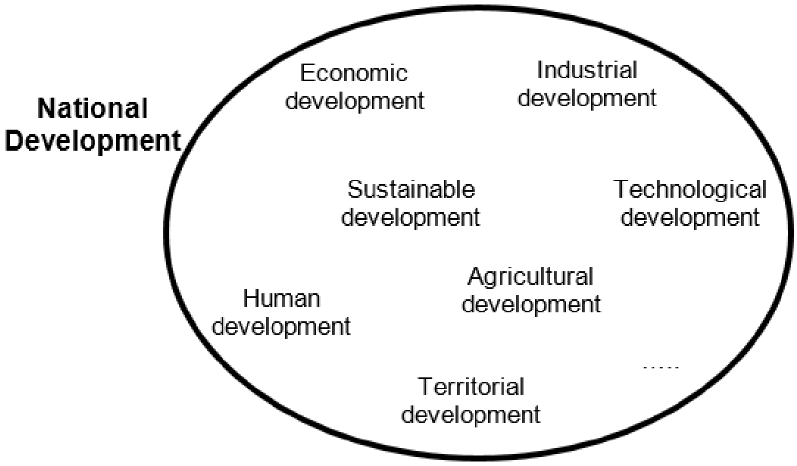
2.1 Development: a multifaceted concept

Development is defined as "the gradual growth of something so that it becomes more advanced, stronger…".[2] It usually means improvement. National development is a multi-dimensional concept as it refers to the development of a highly complex system, often referred to as socio-economic system, i.e. a nation or a country. The literature usually addresses national development either as a whole system composed of several interacting elements (referred to as subsystems) or from a focused subsystem perspective (e.g. economic development, human development, sustainable development, territorial development, technological development, industrial development and agricultural development) (Figure 2-2).

Figure 2-2: National development components



Source: Author.

Due to a nation's system complexity, national development "can occur in different parts or ways, at different speeds, and driven by different forces".[3] Therefore, mixing successfully too many entangled subsystems with diverse objectives within a multitude of contexts (national and international) is clearly an enormous challenge. Thus, defining national development might be more a matter of understanding the relationships dynamics among the system's components and their relative significance in the changing nation's system of values over time.

The appropriate way to address national development is to adopt a holistic perspective, gathering all socio-economic components. However, the complexity of such a perspective has led scholars to adopt more practical approaches towards policy making and managing development. These approaches emphasise development system components. Component identification occurs progressively over the long-run in the light of intellectual (academics and practitioners) debates along with insights enabled by empirical studies.

2.1.1 Economic development

The most traditional component or dimension of national development is economic. Indeed, economic development is a process that generates growth. Scholars identify three major reasons that explain economic growth. The first is provided by Solow,[4] who argues that the accumulation of capital or increasing the capital per unit of labour increases productivity and economic growth in per capita terms. The problem is that continuous increases of capital progressively diminish marginal productivity. Beyond a certain point, any increase in capital would have no impact on productivity per unit of labour. A more adroit solution would be to have capital and labour increase in tandem.[5]

In the context of developing countries the capital/labour ratio is low. Solow's argument essentially means that by investing in capital, developing countries will have more returns than developed countries as the latter enjoy higher capital/labour ratios. Ultimately both developing and developed economies would converge (capital/labour ratios would converge) – a questionable assumption which points up the limitations of this line of argument.

The second reason proffered to explain economic growth is known as Schumpeterian growth. Schumpeter[6] suggests that long-term economic growth is generated to a large extent by innovation. Economic agents or entrepreneurs introduce innovations, including new technology, to their businesses in order to improve them and destroy the results of earlier innovations. This continuous innovation introduction/destruction cycle is the key driver of long-term growth.

The third reason explaining economic growth is specified by North.[7] He remarks on the relationship between institutional change and economic growth. Institutions are defined as "humanly devised constraints that structure political, economic and social interactions".[8] Put differently, institutions are the formal and informal rules used by society to ensure market order and safety. As it is often risky to operate in a market, rules reduce this risk and underpin market development and expansion.

Stiglitz[9] points out the prevalence of market failure in developing countries and the institutional role for government intervention. He emphasises that knowledge and information are associated with "commodities" that are most often linked to market failure. Thus, knowledge becomes central to economic development. Economic development is then defined as "a process of moving from a set of assets based on primary products, exploited by unskilled labour, to a set of assets based on knowledge, exploited by skilled labour".[10]

2.1.2 Human development

Economic development is not an end per se, but should enable human development.[11] The latter refers to another important development dimension. The United Nations Development Programme suggests capturing human development through the aggregation of three basic measurements: length of life and health, knowledge, and living standards.[12] Thus the notion of knowledge becomes central to human development. It empowers people, expands their opportunities, promotes creativity and personal freedom.

Economic development and human development are mutually reinforcing. Soubbotina reveals that "during 1960-1992, not a single country succeeded in moving from lopsided development with slow human development and rapid growth to a virtuous circle in which human development and growth can become mutually reinforcing".[13] Mankiw et al.[14] and Grossman & Helpman[15] highlight the significant impact of appropriate and motivated human capital on economic growth.

2.1.3 Sustainable development

Both economic and human development should not be achieved at the expense of the environment or future generations or by jeopardising the well-being of people living elsewhere. These concerns have led to the emergence of the concept of sustainable development, which was first defined by Brundtland.[16] She considers development as sustainable if it "…meets the needs of the present without compromising the ability of future generations to meet their own needs".[17] According to Elkington,[18] the triple bottom line of sustainable development consists of economic, social and ecological components. They are all critical to human development – in terms of ensuring economic prosperity, social equity and environmental quality.

Indeed, sustainable development ties in closely with socio-economic development. Ashfors & Caldart[19] illustrate the multitude of non-market- and market-based decisions, and beyond that the economic and competition regulations that comply with environmental issues (e.g. protection, control and exploitation) and maintain the economic value of environmental resources and amenities. They argue that sustainable development also has a social sustainability dimension that manifests itself through sustainable life quality, sustainable health, sustainable employment and knowledge. Munsasinghe & Lutz[20] discuss the ecological component of sustainable development and emphasise the need to maintain the resilience and robustness of biological and physical systems.

In addition to the above national development components, several other components are identified such as industrial development, technological development, agricultural development and territorial development (Figure 2-2). They often have diverse but overlapping objectives and balancing them is challenging for any country. Cross-linkages among the nation's development components are complex and difficult to untangle. For this reason, the focus in the following section is on the technological dimension of development, particularly in the context of developing countries, as it underpins the present thesis' purpose.

Due to the fact that development is often informed by theories and ideas generated in developed countries,[21] the implementation of those theories and ideas has proven difficult because of developing countries' peculiarities and context.

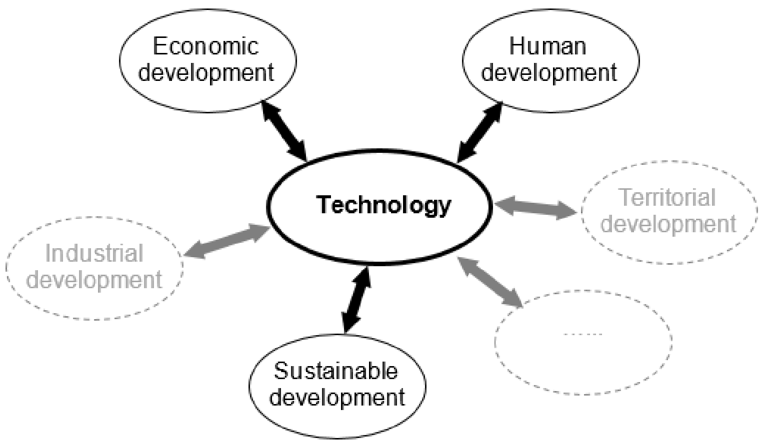
Another difficulty is that of defining and characterising developing countries. According to the contemporary literature on development, developing countries are defined as states trying to catch up with developed countries along multiple dimensions: economic, human, sustainable, technological, territorial, and so forth. Several indices[22] are currently used by international organisations to rank countries' development. However, none of them is thought of as comprehensive of emerging global development issues.

Due to this operational uncertainty as regards country development levels, the World Bank classification, one of the oldest and most conventionally accepted, is adopted for the purpose of this study. The World Bank classifies countries against four categories based on Gross National Income (GNI) per capita: Low Income, Lower Middle Income, Upper Middle Income and High Income. Low and Middle Income are conventionally referred to as developing countries. Based on this classification, Algeria falls under the category of developing countries with Upper Middle Income.[23]

2.2 Technology and development

Technological progress can either be seen as a component of national development per se or as an agent contributing to the development of other components such as economic, human and sustainable development (Figure 2-3). This section proposes to explore the relationships from the latter perspective.

Figure 2-3: Technology as a development agent



Source: Author.

2.2.1 Technology: 'the' lever for economic development

Malecki[24] considers technology as an evolving multi-dimensional concept referring to the "capabilities of human society to transform nature into useful products for human consumption".[25] Storper & Walker[26] state that technological evolution occurs through a multitude of dimensions that technology encompasses.[27] Solow[28] studies the impact of technological evolution on American living standards between 1909 and 1949. He finds that much of the improvement stems from technological progress. He then infers that technological progress is the dominant factor in long-term economic growth. Building on this idea, Mansfield[29] argues that the rate of technological change is the most dominant factor affecting the rate of economic growth.

Kim[30] stresses the role of technology in supporting long-term economic growth in industrial countries. He recalls some studies that showcase the role of technology in improving productivity and enabling new products, processes and industrial development. The World Development Report[31] makes clear that improvement in productivity as a consequence of technological progress is a significant factor explaining the rapid growth of East Asian GDP. Kondo[32] considers technology progress as a key element in international competitiveness and economic growth. He illustrates the technological impact on productivity through the production function, highlighting the fact that technological progress is the only input that increases wealth without increasing capital or labour.[33]

Endogenous vs exogenous technological progress

The previous debate leads to the fundamental question as to whether economic growth is based on endogenous or exogenous technological progress. Supporters of the exogenous thesis led by Rostow[34] claim that long term economic growth is primarily induced by external factors. The exogenous growth model draws on the assumption that technology is generated outside the socio-economic system and is 'easily' transferrable into that system. In the context of developing countries, this means that economic growth can be enjoyed merely through transferring technology from abroad, which is clearly too ‘simplistic’.

Noting the weakness of the exogenous growth theory, Romer,[35] supported by other scholars,[36] propose an endogenous growth theory. They argue that internal investment in education, R&D, innovation and knowledge will bring about technological change, the engine for economic growth. For the spill-over effect to be significant, emphasis has to be placed on indigenous effort, such as policies supporting R&D, education, human capital and incentives for innovation. The institutions’ role, as defined by North,[37] is vital in promoting endogenous technology progress. At country level, this role includes, for instance, government measures to encourage innovation, knowledge, and enforce property rights, traded off against taxation that may hinder progress, as explained by Barro.[38]

A major question is raised regarding the appropriateness of endogenous growth theory in business start-ups and during early stages of development. Bellu[39] points out that the spill-over effects of investment in technological learning, on which this theory is based, are built on the assumption that businesses have already started and processes are ongoing.

Here many scholars push for exogenous growth theory by using external factors such as foreign investment and technology transfer that can be used to start up activities. Once the required accumulation level is reached in terms of capital and technological knowledge, an endogenous growth model or a mix (exogenous-endogenous) can take over. This approach seems to be relevant to developing countries.

However, sounding a note of caution, Bellu raised the inherent difficulties of shifting from an exogenous to an endogenous growth model since “extraneous production modalities, retained or disguised information on know-how by investors, associated with missed control on capital accumulation processes by local actors, for instance, due to stealth expatriation of profits, may hamper the accumulation of capital”.[40] The difficulties “may also affect the endogenous generation of innovations by blocking learning-by-doing dynamics, hampering the empowerment of local actors and jeopardizing the appropriate use of local endowments".[41]

2.2.2 Technology and human development

As regards the relationship of technological progress to human development, the UN Human Development report emphasises the necessity to use technological progress and wealth for the benefit of people.[42] On this topic, it is worth mentioning that technology is considered as particular kind of knowledge[43] and that the centrality of the latter to human development is acknowledged,[44] not least through the increasing impact "technological" knowledge has on quality of life, education, employment and work patterns.[45] The impact is arguably fostered by the phenomenal development of information and communication technologies.[46]

2.2.3 Technology and sustainable development

Sustainable development is typically affected by current consumption models adopted by societies around the world, as well as by population growth and technological development.[47] Governmental margins of manoeuvre are very tight when it comes to reducing the impact on the environment by changing consumption models or limiting population growth. This demonstrates the vital role technology (or environmentally friendly technology) has as a lever for sustainable development.

A number of studies argue that a noteworthy range of technologies that can contribute significantly to sustainable development is already available in the public domain. However, these technologies are not easily accessible because of their cost or the lack of appropriate knowledge for their acquisition.[48]

Technology is knowledge: a cross-cutting concept that can be considered a public good.[49] Stiglitz[50] emphasises the responsibility of the international community to disseminate knowledge, as its importance goes beyond national or regional boundaries. Knowledge dissemination or transfer can then occur internally or across borders. However, the bulk of knowledge is generated in a very limited number of developed countries. Consequently, accessing it in the context of developing countries is a matter of transfer from abroad. It is also a matter of internal endeavour to absorb this knowledge. This combination parallels the exogenous-endogenous mixed growth model discussed earlier.

Other considerations should be taken into account, including that the transferred technology is not always up-to-date, enabling sustainable development to occur. For that reason, the technological progress dynamic should be considered in the development model design, as suggested by Ashford & Caldart.[51] It is essential to note that the debate in this realm remains dominated by market perspectives, and nourished by the economic literature.

Having discussed national development dimensions and the role technology is playing, the following sections discuss issues that are germane to technological capability-building through technology transfer, focusing on developing countries.

2.3 Technology transfer and technological capability-building: a knowledge acquisition process

Prior to getting into a more detailed discussion on technology transfer and technological capability-building, the concept of technology should be defined. There has been a proliferation of different technology definitions over time. These definitions stem from multiple perspectives in accordance with the transformations that human societies have experienced.

Toffler[52] explains that development in societies has occurred in three waves. The first wave was agricultural society dominated by labour and natural resources (land). Industrial society was the second and it was capital-intensive. The third wave is the service/information society, and it is knowledge-intensive. Drucker[53] qualifies the transformation that took place immediately after World War II as transition towards a post-capitalist or knowledge society. The ‘knowledge’ qualification comes from the fact that the main production factor in the new society is knowledge and not capital, labour or land.

From this standpoint, Mokyr[54] defines technology as a particular kind of knowledge which “in its basic form, consists of instructions or recipes on how to make things or supply a service. But these instructions are based on background knowledge of natural phenomena and the regularities that can be exploited to yield these instructions. As people learn more about nature and the physical world, they can write better instructions and enjoy better ways to manipulate nature; that is, to produce”.[55]

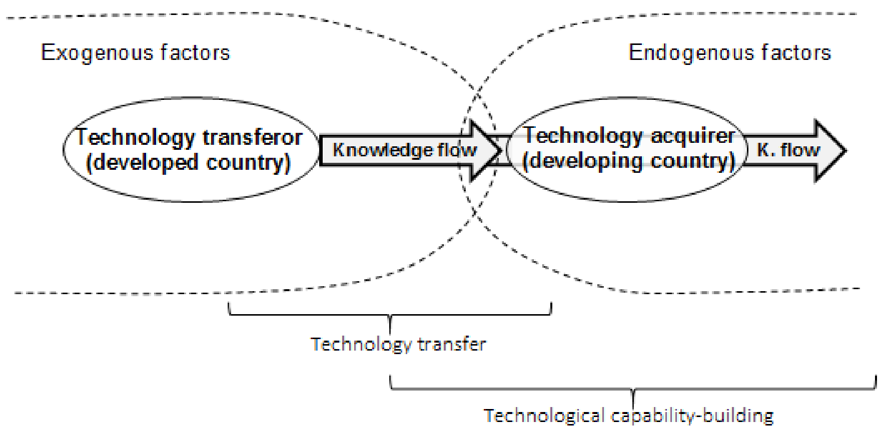
Storper & Walker[56] identify elements involved in technology which can be classified into products (goods: equipment and products), processes (production techniques), and knowledge (social knowledge and skills).[57] The concept of knowledge, then, is central when discussing matters related to technology transfer and technological capability-building.

Technology transfer refers to knowledge transfer. This is why Chen[58] argues that defining the concept of technology transfer is difficult – because technology is knowledge and not a product. He explains that transferring technology goes beyond its mere acquisition from abroad, principally because it also aims to build national technological capabilities.[59] Odedra[60] and Gohen[61] highlight the confusing, complex and multi-dimensional aspects of technology transfer, which gives rise to the multitude of definitions used in the literature.

For the purpose of this study, technology transfer refers to knowledge acquired by an organisation situated in a country different from that in which the knowledge was generated, with the acquirer’s intention to use it indigenously, to adapt, modify, improve, and even innovate from it.[62] On the other hand, technological capability-building refers to the acquirer’s “ability to make effective use of technological knowledge in efforts to assimilate, use, adapt and change existing technologies. It also enables one to create new technologies and to develop new products and processes in response to a changing economic environment”.[63]

Put differently, technology transfer reflects a system involving exogenous factors, while technological capability-building involves endogenous factors (Figure 2-4). However, both technology transfer and technological capability-building are concepts that revolve around knowledge acquisition or technological learning. A caveat here should be added: the linear representation of the knowledge flow (Figure 2-4) from the technology transferor to the transferee and then to the local diffusion should not overshadow interactions and knowledge that flows in the opposite direction.

Figure 2-4: Technology transfer and technological capability-building



Source: Author.

2.4 Technological learning

The following discussion is in line with the resource-based view of the organisation.[64] This school of thought views knowledge as a resource at the core of developing and assembling other resources within the organisation.[65] The ability to acquire, appropriate, and diffuse knowledge (i.e. learning) is crucial for the organisation. This section reviews some knowledge and learning typologies and learning theories that are relevant when specifying technological development.

2.4.1 Tacit vs explicit knowledge

Knowledge is a heterogeneous resource that can take an explicit or a tacit form. According to Sanchez,[66] knowledge is explicit when it is declarative, factual and can be codified (either verbally or in writing). Nonaka & Takeuchi[67] and Nonaka[68] define tacit knowledge as subjective, personal and created within a specific context. Polanyi[69] distinguishes tacit from explicit knowledge by its latent nature. He offers the example of a person's ability to recognise human faces without the ability to fully explain how. Unlike explicit knowledge, tacit knowledge cannot be conveyed through codified form. It is accumulated through practice and experience.[70]

In the technological and industrial context, knowledge is very often thought of as a resource that includes two complementary (tacit and explicit) components, and seldom one without the other.[71] For effective learning in the technological milieu, there is a need to coalesce explicit (codified) knowledge and implicit (tacit) knowledge.[72]

However, the difficulty in conveying implicit knowledge lies mainly in the fact that it resides in individuals and cannot easily be shared. The challenge then is to first diffuse it through the organisation, as it may be lost or transferred elsewhere if individuals leave the organisation.[73]

Moreover, conveying implicit knowledge in a technology transfer context is difficult even if face-to-face communication is used between the transferor and transferee. This is due to the difficulty of codifying such knowledge. And, even when knowledge is codified, interpreting it may be difficult due to cultural and communication reasons, such as differences in languages and codification practices used. Cowan et al.[74] argue that the difficulties grow more acute in person-to-person learning because of the idiosyncratic and particular personality of each person.

2.4.2 Learning levels: individual, group, organisation and inter-organisation

The literature on learning conventionally identifies several learning levels: individual, group, organisation and inter-organisation.[75] The individual level is foundational, in the sense that effects at that level can be enriched and converted through interactions into group opportunities and then embedded and amplified into the context of an organisation or inter-organisation.

Gill[76] argues that individual learning depends both upon individuals and the organisation. The former have the responsibility to seek their own development; the latter has the responsibility to offer an environment conducive to learning. By learning, individuals should attempt to build capacity to achieve the organisation's goals and not simply seek their own personal interest.

Group learning occurs when knowledge is held by the group as a whole and not by any single individual.[77] It results from individuals who share group values and contribute to achieving the group's goals. According to Russ-Eft et al.,[78] knowledge resulting from group learning is a continuous accumulative process of knowledge about the organisation, the group and the individuals. When dealing with group learning, Kim[79] suggests considering the group both as a mini-organisation and as an extended individuals. In the former case, individuals have their own shared values and can even provide a parallel learning structure within the organisation. In the latter, individual groups are influenced by organisational management and structures.

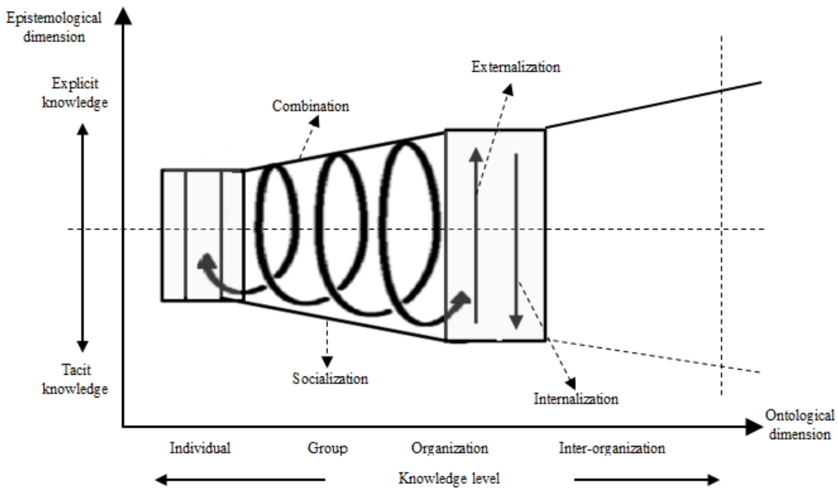
Organisational learning does not stem from mere aggregation of individual learning, but hinges upon further factors. Dasgupta[80] identified seven variables that may impact organisational learning: (i) individual learning, refers to the individual's 'separate' role in the organisational learning process; (ii) process and systems, refer to the individual learning processes gathered within the organisation as a learning system; (iii) culture and metaphor, required to shape values that guide personnel behaviours; (iv) organisation memory, involves recorded experience structures and processes for retrieving this experience; (v) knowledge management, refers to a multi-disciplined approach that aims to manage organisational knowledge[81] resulting out of organisational learning – this approach involves processes for creating, capturing, developing, sharing and effectively using organisational knowledge;[82] (vi) continuous improvement, refers to continuous organisational learning processes adopted by the organisation; and (vii) creativity and innovation, refers to the organisational mechanism used to convert continuous learning into incremental innovation.

Nonaka's model of organisational knowledge creation

Nonaka[83] argues that learning results from a combination of two dimensions. The interplay between individual and organisation learning, and the interplay between tacit and explicit knowledge. Knowledge can then be conveyed during learning through four modes. The first, called "socialisation", refers to the conversion of tacit knowledge held by an individual(s) into another form of tacit knowledge held by another/other individual(s) (e.g. through on-job-training). The second, called "combination", refers to the situation where an individual(s) receive(s) pieces of explicit knowledge from another/other individual(s) and creates from them new explicit knowledge (e.g. knowledge reconfiguration and recontextualisation). The third process is referred to as "externalisation". It occurs when tacit knowledge is converted to explicit knowledge. The fourth process is called "internalisation". It occurs when explicit knowledge is converted to tacit knowledge.

Nonaka's four modes of knowledge creation are represented through a model (Figure 2-5) that shows the spiral dynamic of knowledge creation. Nonaka argues that organisational knowledge will exist separately from individual knowledge when the four knowledge creation modes exist and are managed simultaneously. For instance, he points out that a team (or field) setting can trigger socialisation. Meaningful dialogue between actors (successive rounds) can trigger externalisation. Organisational units and team member coordination along with existing knowledge use (e.g. data, documentation) can trigger combination. Learning by doing (or the process of trial-and-error) builds experiences that can trigger internalisation. Noteworthy is that the upward spiral process starts from an individual and moves towards collective levels (group, organisation, inter-organisation) and illustrates knowledge creation amplification.

Figure 2-5: Nonaka's model of organisational knowledge creation



Source: adapted from Nonaka, I., 1994. A Dynamic Theory of Organizational Knowledge Creation. Organization Science 5, 14–37.

Experiential learning at individual, group, organisation and inter-organisation levels

Experience has been emphasised by many scholars[84] as a major catalyst in the learning process at individual level. Kolb's Experiential Learning Theory (ELT),[85] particularly its cyclical model, has had a dramatic impact on learning literature at this level. Beyond the individual level, past experiences have a role in shaping the learning dynamic at other levels of analysis (group, organisation and inter-organisation).

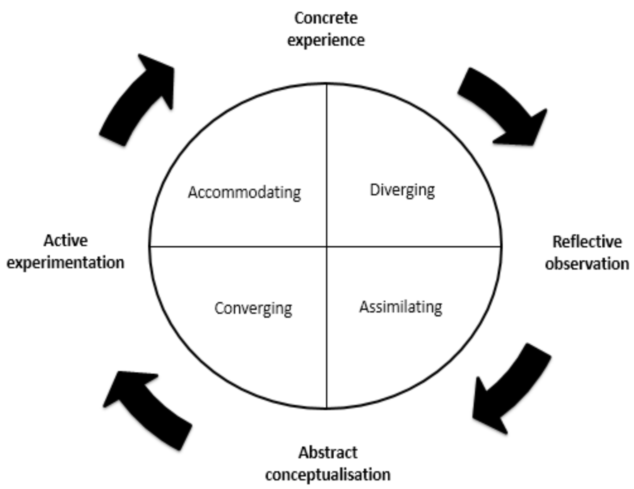
The present subsection examines Kolb's ELT and its extensions beyond the individual (which was Kolb's original focal level of analysis) to other levels of analysis (group, organisation and inter-organisation). This is to show how Kolb's

ELT is adapted to learning programmes which lend themselves to multi-level analysis.

a) *Kolb's Experiential Learning Theory: a framework for individual learning*

Kolb defines learning as "the process whereby knowledge is created through the transformation of experience".[86] He claims that "knowledge results from the combination of grasping experience and transforming it". [87] He dissected this vision into a model of a four-stage learning cycle (Figure 2-6) and argues that learning is effective when it is holistic and combines experience, perception, cognition and behaviour (referred to as concrete experience, reflective observation, abstract conceptualisation and active experimentation).

Figure 2-6: Experiential Learning Cycle and basic learning styles



Source: Adapted from Kolb, D.A., 1984. Experiential learning: Experience as the source of learning and development, Prentice-Hall, Inc., Englewood Cliffs. New Jersey.

Kolb emphasises that learning is effective when it is holistic. Fundamentally, this happens when both dimensions, reflection and action, are combined during the learning process. However, Kolb recognises the conflict between these two dimensions of learning whereby the learner "moves in varying degrees from actor to observer, and from specific involvement to general analytic detachment".[88] These opposing tensions are constantly at play and require individuals to combine reflective abilities (theoretical) and action (concrete and practical).

Kolb explains that combining conflicting abilities is not always a natural task. He explains that individuals thrive from their own experience, based on their own set of learning abilities which they use comfortably. Put another way, individuals develop their particular learning styles throughout their lives. Four learning styles are therefore identified (Figure 2-6): diverging, assimilating, converging and accommodating.[89] Each individual tends to enter the learning cycle from the point that corresponds to his strongest abilities (or preferred style), and the whole cycle then needs to be completed for learning to be effective.

b) Experiential Learning Theory expanded to group learning

There is a need to continuously develop individual skills for teamwork. Mills[90] describes this dynamic as involving successive and increasingly sophisticated levels of abilities for a team which faces increasingly sophisticated purposes. Kayes et al.[91] regard these purpose orders as team developmental stages. They argue that Kolb's ELT can be used as a framework whereby a team moves from lower to higher stages. They bring to light two fundamental aspects of team experiential learning. Firstly, the incidence of a conversation space for the team where members talk about their experience, reflect on actions and consequences, and share the desire to grow together. Secondly, the ability of team members to evolve from individual roles to shared responsibilities and team roles.

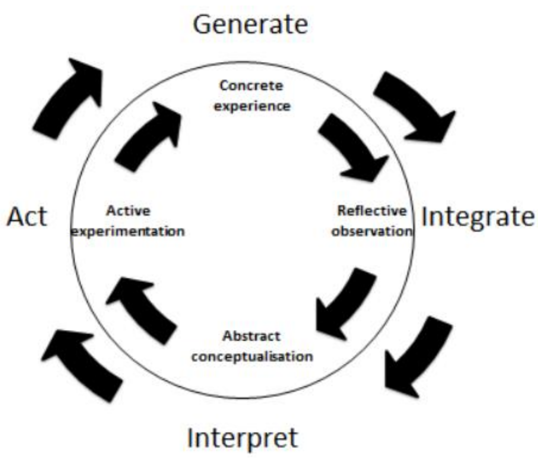
For these conditions to be met, Kayes et al.[92] argue that teams should enter the experiential learning cycle and "must have members who can be involved and committed to the team and its purpose (concrete experience), who can engage in reflection and conversation about the team's experiences (reflective observation), who can engage in critical thinking about the team's work (abstract conceptualisation), and who can make decisions and take action (active experimentation)".[93] Put another way, teams must be composed of members with diverse learning styles (Figure 2-6).

c) Organisational learning cycle and Kolb's Experiential Learning Theory

An early indication of the relevance of the Kolb ELT for an organisation is provided by Swieringa & Wierdsma.[94] They explain that organisations learn effectively when they combine reflection and action. They argue that "while [Kolb's cycle] is true for individual learning, it is even more so for a collective learning process, a process of organizational learning".[95]

Dixon[96] addresses the connection between organisational learning and Kolb's experiential learning cycle by suggesting that the phases of learning which take place at individual level bear relation to the collective context.[97] She offers a four-phase model inspired by Kolb's learning cycle and fitting the organisational context (Figure 2-7).

Figure 2-7: Organisational learning cycle and Kolb's experiential learning cycle



Source: adapted from Dixon, N. 1999. The organizational learning cycle: How we can learn collectively. Gower Publishing, Ltd, p.65.

The initial step of the cycle deals with 'concrete experience'. In this phase and in order to better deal with complexity, organisations need to diversify and broaden their sources of information (generating information). Subsequently comes a phase of integration of information corresponding to Kolb's 'reflective observation'. The next step is the collective interpretation of information relating to 'abstract conceptualisation' in the Kolb model. The final step is action and corresponds to ‘active experimentation’. The actions taken will serve as sources of new information.

d) Inter-organisational learning cycle and Kolb’s Experiential Learning Theory

Hargadon[98] highlights the importance of inter-organisational experience for learning. Experience is built over time through dense and continuous interactions between organisations. Beeby & Booth[99] reject the assumption that inter-organisational relations are inherently competitive. They put forward the need for complementarity and integration between organisations, similar to that needed between departments of the same organisation. They then draw connections between Kolb’s cycle and inter-organisational learning. Their proposal is based on Coghlan’s[100] inter-departmental framework, where learning at inter-departmental level is modelled according to a Kolb-like cycle (Experiencing-Processing-Interpreting-Taking action).

e) Interplay between learning levels

The previous discussion purports that learners, whether they are individuals, groups, organisations or inter-organisations, might be more effective when completing Kolb-like cycles. It suggests that experience-based learning models can contribute to the study of knowledge transfer at separate levels of aggregation. However, there is a need to recognise that learning is a more complex phenomenon insofar as processes occurring at separate levels are in fact interrelated.[101] A number of authors suggest that successful learning leads to a systemic phenomenon where the interplay involves all levels of aggregation, from individuals to inter-organisations.[102]

It is important to recall that the idea of discussing the potential of Kolb-inspired experiential theory and models in technology transfer comes from the need for evaluation of comprehensive technological learning based on experience. However, in the context of developing countries, achieving a tension-filled process combining action (practical aspects) and reflection (theoretical aspects) is challenging. Many developing countries have had limited exposure to full learning cycles combining action and reflection.[103] The following situations reveal the absence of established practices in holistic learning. The development strategy of numerous developing countries relies on knowledge acquired from abroad combined with knowledge generated endogenously. In the former case, studies revealed that this strategy often overemphasises the action and practical aspects of learning (e.g. through industrial programmes, consulting) and overlooked the theoretical basis underlying the transferred knowledge.[104] With regard to the latter, it is acknowledged that when the strategy is based on endogenous development, the role of local education is crucial.[105] However, because of limited local financial and managerial resources, indigenous education (or human skills development) systems in many developing countries marginalise practical work and experimentation and limit education to some theoretical aspects.[106] In both strategies, the learning cycle is interrupted; consequently, many developing countries have not enough exposure to effective learning processes where action and reflection were successfully combined.

2.4.3 Knowledge velocity vs knowledge viscosity

Davenport & Prusak[107] introduce two concepts that are essential when discussing issues of knowledge transfer effectiveness: “velocity” and “viscosity” of transfer. Velocity refers to the “speed with which knowledge moves through an organisation. How quickly and widely is it disseminated? How quickly do the people who need the knowledge become aware of it and get access to it?”[108] On the other hand, they consider that viscosity represents the “richness (or thickness) of the knowledge transferred. How much of what we try to communicate is actually absorbed and used? To what extent does the original knowledge get pared down? Does what was absorbed bear little resemblance to what we tried to transmit and retain little of its original value?”[109]

Davenport & Prusak[110] consider also that ICT (e.g. computers, networks) contribute strongly to enhancing knowledge velocity, whereas factors such as the transfer mode influence viscosity. For instance, the mode that fosters the long process of apprenticeship or mentoring relationship contributes more to enhancing knowledge depth or viscosity through subtle knowledge and many details conveyed during the process. Viscosity, according to Schwartz et al.,[111] will be much thinner if knowledge is made accessible only through scientific journals or on-line database.

Davenport & Prusak[112] stress, along with Lall,[113] that absorption of new knowledge is a slow, sometimes long and laborious process. Davenport & Prusak[114] also argue that successful knowledge transfer is usually achieved through a delicate balance between velocity and viscosity. They argue that the relationship between velocity and viscosity is indirectly proportional, as often the factors that lead to high velocity are those leading to thin viscosity and vice-versa. Schwartz et al.[115] support that argument and contend that in general the transfer mode adopted is a compromise between high velocity and acceptable viscosity.

Failure to reach the right velocity-viscosity compromise is reminiscent of the multiple technology transfer failure stories. Indeed, Matthews[116] reveals that India's foreign collaboration in machine tool manufacture during the 1970s proved to have little impact on local capability-building. Felker[117] points out that the FDI policies adopted by Malaysia in the 1990s lead in some industrial sectors (e.g. electronic and automobile industries) to a shallow form of industrialisation. For the same country, Balakrishnan[118] notices the limited depth of foreign technology transfer into the defence industry during the 1990s-2000s. Furthermore, Yan[119] observes the limited depth of foreign collaboration in the aerospace industry in the 2000s.

2.4.4 Component vs architectural knowledge

Henderson & Clark[120] argue that successfully developing a technological product requires two types of knowledge: component knowledge that relates to the core design concepts for each component of the product, and architectural knowledge that relates to the way that components are put together to form the system (or the product).

In technology-oriented industries, Tallman et al.[121] contend that component knowledge is “relatively coherent and definable, and is usually acontextual”.[122] Henderson & Clark[123] claims that it remains subject to incremental changes and is managed explicitly. Consequently, component knowledge has the potential to be transferred to informed learners.[124] However, the flow remains dependent on the degree of knowledge explicitness: on whether it is simple vs complex, independent vs systemic, and on whether it is tangible vs intangible.[125] Matusik & Hill[126] describe component knowledge as related to subroutines or parts of the organisation’s operations, rather than the whole. Both individuals and groups within the organisation can hold this type of knowledge.

Architectural knowledge, on the other hand, refers to “organisation-wide routines and schemas for coordinating the various components of the organisation and putting them to productive use”. [127] Architectural knowledge is built collectively over time, shaped by the organisation’s idiosyncratic events and its evolutionary path.[128] It is built by encouraging interactions. This knowledge is typically complex, intangible, tacit, and organisation-specific, which makes it difficult to transfer.[129] Henderson & Clarck[130] claim that once a technological system’s dominant design is accepted, architectural knowledge becomes stable and implicitly embedded in the organisation.

Baldwin[131] suggests that architectural knowledge includes “knowledge about how the system performs its functions (the function-to-component mapping)”,[132] the knowledge about “how the components are linked together (i.e. the interfaces)”,[133] and the knowledge about how the system performs or behaves in both planned and unplanned situations and in different environments.

Henderson & Clark[134] claim that the architectural knowledge already rooted in the organisation makes it hard for the organisation to build new architectural knowledge. It needs to switch to a new mode of organisational learning that fosters architectural changes. This new learning mode should be explicitly recognised, managed, and might require new organisational structure and new skills more appropriate to architectural knowledge (e.g. systems engineering).

Henderson & Clark[135] point out therefore that an "organisation that is structured to learn quickly and effectively about new components technology may be ineffective in learning about changes in product architecture".[136] Hence the need for a more open organisational environment and cross-functional or multi-disciplinary teams. This is also a challenge for organisations: to avoid the situation where architectural knowledge leads them to a comfortable feeling that may encourage competitors (mainly new entrants) to take advantage of major component or architectural changes.

Moreover, building a strategy on the preservation of a stable architecture (i.e. same architectural knowledge) is generally possible by modularising technological systems and intervening only on modules that need to be changed while keeping the remaining modules unchanged.[137] Such a strategy is limited as modularising is acceptable only to a certain level beyond which the complexity cost becomes unbearable.[138]

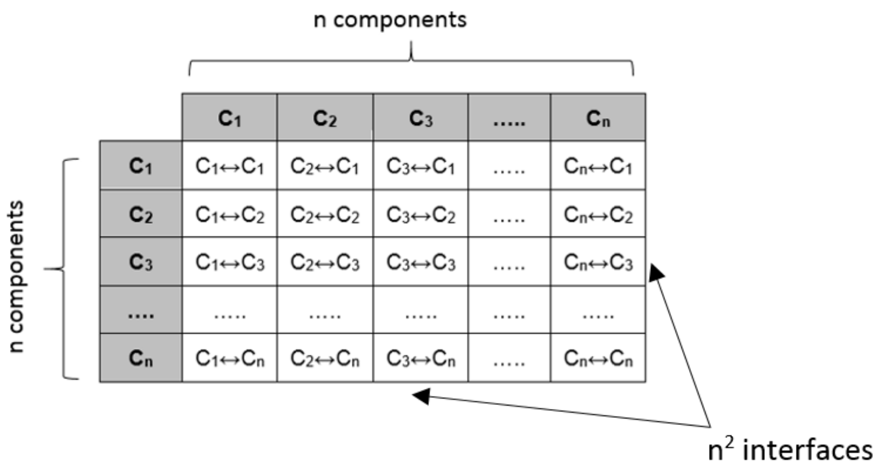
For acquiring technology, the literature on strategy and innovation suggests that organisations with limited resources, such as those in developing countries, need to make a trade-off between architectural and component knowledge. Indeed, under the inherent complexity of a technological system, the organisation (or learner) may be so focused on building integrative capabilities (architectural knowledge) that component knowledge is neglected, and vice-versa.

Based on transaction cost economics, Teece[139] argues that small firms are more suited to generating autonomous innovation. Such innovation relates to the development of a new component, which enables it to fit comfortably into the existing system. Conversely, large firms are more suited to generating systemic innovation. The latter relates to the development of new architecture, leading consequently to further coordination problems.

In the same vein, Jacobides & Winter[140] show that the optimal choice for firms with financial constraints is to narrow the initial scope. Baldwin[141] recognises the difficulty of striking the right balance and proposes a strategy that resource-limited firms can adopt. She suggests that firms narrow their initial scope by focusing on learning internally about particular components (i.e. crucial components, sometimes called 'bottleneck' components) and outsourcing the non-bottleneck components.

From a system engineering perspective, a system with n components (Figure 2-8) may require n² interfaces that need to be integrated and tested.[142] Thus, if the number of components increases (which can be considered as an increase in component knowledge), coordination problems increase (which can be considered as a decrease in architectural or integrative knowledge).

Figure 2-8: Number of interfaces in a system with n components



Source: Author.

Consequently, and similarly to the delicate balance sought between velocity and viscosity to achieve successful knowledge transfer, the literature acknowledges the inversely proportional relationship between the number of components (or component knowledge) and the architecture (or integrative knowledge) when it comes to resource-limited firms.

2.4.5 The triad: learning by doing, learning by searching and learning by interacting

This typology is one of the most prominent in technological learning. It identifies three types of learning: learning by doing, learning by searching and learning by interacting.

Learning by doing

Arrow[143] recalls that learning results from experience or what is referred to as learning by doing. Knowledge is accumulated progressively by repeating production activities and attempting to solve problems faced. Bell[144] argues that learning by doing takes place as a by-product of production.

At an organisational level, Argote & Epple[145] explain that depreciation in learning by doing may be caused by factors such as organisational forgetting (e.g. interruption in production, non-employment of knowledge, employee turnover, losses in knowledge transferred from other products or organisations, as well as growing use of economies of scale that may mask a decrease in learning rate. UNIDO[146] stresses the importance of routine management in the process of learning by doing. Teece[147] explains that learning by doing is not as automatic as is considered and requires explicit efforts.

Learning by searching and learning by playing

Bell[148] recognises that besides learning by doing that aims to increase production using the same technological capability, further learning types exist. It is required to, first, improve the existing technological capability and, second, to move to another and new kind of technological capability. Dosi[149] refers respectively to these two options as continuous change along the same technological trajectory, and discontinuous change associated with the emergence of new technology (discontinuities in technological innovation). Both changes might result from an active learning process called learning by searching.

As with learning by doing, learning-by-searching knowledge accumulation is path-dependent, as it builds on prior knowledge.[150] Searching involves experimentation and simulation to understand phenomena. Nelson & Winter[151] and Malerba[152] explain that R&D activities are a significant enabler of learning by searching whether they are endogenously conducted through formal R&D, or exogenously by carrying out a technology watch (e.g. scientific and technological publications, seminars, patents analysis).

It is expedient at this stage to stress the analogy between learning by searching and learning by playing. De Geus[153] argues that the best way to make learning effective and to accelerate its pace is to make skilful use of 'playing', as "the essence of learning is discovery through play".[154] Playing here refers to the situation where learners can experiment, or play with, an object that they hold in their hands. This object may range from a basic technological product to a complex technological system such as a satellite.

Winnicott[155] emphasises that the idea of playing with objects enables learners to move from one stage to another. Moreover, de Geus[156] explains that the more in-depth the game or the experiment is, the more learners' imagination is triggered and the more knowledge is acquired. Eilertsen & London[157] stress the importance of protecting learners from reprisal when they are experimenting, or playing, with objects, because they may make mistakes.

Arrow[158] and Nelson[159] point out the fact that learning by searching is not encouraged in firms because of the likely rapid dissemination or leakage of knowledge that might be created. This is why there is a need to entrust this task to government-sponsored organisations.[160] The enforcement of intellectual property rights helps promote learning by searching within the private sector,[161] and encourages firms to engage in continuous learning-innovative activities to outperform the competition.[162]

Learning by interacting

Malerba[163] considers that interaction enables knowledge acquisition from external sources. Upstream and downstream (e.g. suppliers and customers) interactions are referred to as vertical or value chain interactions. Horizontal interactions refer to cooperation with horizontal organisations such as firms in the same industry that may belong to the same supply chain, as well as research organisations.

Horizontal cooperation is more likely to produce a discontinuous change (technological innovation) than vertical interaction.[164] The latter leads to more continuous change along the same technological trajectory (i.e. incremental innovation). However, in today's ever-changing environment, knowledge created through vertical interaction does not necessarily accumulate and is not necessarily path-dependent.[165] Kenney[166] provides the example of highly knowledge-intensive industries such as electronics and computer networking where the pace of new knowledge creation may destroy the recently created knowledge value. He therefore suggests examining the impact of such a dynamic on the firm and whether its core competencies are built on more static knowledge components that may shield the firm against the threat of knowledge obsolescence.

Complementarity between learning by doing, learning by searching and learning by interacting

When learning by doing, by searching and by interacting are combined together, the learner's ability to effectively take action increases significantly. Kim[167] illustrates this ability through the example of a carpenter's limited effectiveness if he masters woodworking skills (i.e. knowledge stemming from learning by doing) without mastering knowledge about house structures and architecture (i.e. knowledge stemming from learning by searching) and vice-versa. In the same vein, the present author argues that a carpenter's abilities will be limited if he does not interact (learning by interacting) enough with his environment (e.g. suppliers, customers, other carpenters) to, for instance, find out about techniques used elsewhere, customers' needs and appropriate timber.

2.4.6 Absorptive capacity: a key component of learning

Having discussed the principal concepts relevant to technological learning, the present subsection discusses the importance of learner absorptive capacity for effective learning.

Zahra & George[168] and Zahra et al.[169] explain that absorptive capacity is a concept that relates to two sets of capabilities: knowledge acquisition and assimilation capabilities, and knowledge transformation and exploitation capabilities. Cohen & Levinthal[170] argue that acquiring new knowledge hinges largely on the level of prior related knowledge. The latter allows the recognition of new knowledge value and facilitates this knowledge assimilation and utilisation. Cohen & Levinthal[171] call abilities enabled by prior knowledge "absorptive capacity". Prior knowledge ranges from basic skills to the latest advanced knowledge in the area.

Two major components of absorptive capacity are identified at the organisational level: the existing knowledge base (i.e. prior knowledge or knowledge accumulation) and the intensity of effort. Existing knowledge accumulates over time. It helps develop the ability to recognise new knowledge value, assimilate and then use it. The existing knowledge base grows through continuous learning occurring under normal circumstances.

Intensity of effort refers to the level of effort invested by the organisation to assimilate and utilise new knowledge. It relates more to the discontinuous learning that occurs under abnormal circumstances, i.e. a crisis.[172] According to Meyers,[173] a crisis can be unintentional, stemming, for instance, from the threat of market competition, where the organisation has to acquire new knowledge to negotiate the crisis. On the other hand, a crisis can be intentionally created by the organisation's management or by institutions (e.g. government policy such as import substitution or export promotion) through setting high performance targets or very ambitious goals.[174]

2.5 Technological capability-building

2.5.1 Capability-building, moving along a complexity continuum

As mentioned earlier, national development is heavily dependent on technological change that stems from technological accumulation over time. Relevant literature on technological capability addresses this idea from various standpoints. Kim[175] considers technological capability as a concept indicating the level of organisational capability stemming from the dynamic process of technological learning. He emphasises the need to go beyond the mere possession of knowledge in building technological capability, and instead to use it in investment and production activities, as well as in generating new knowledge. According to him, technological capability and absorptive capacity, as defined by Cohen & Levinthal,[176] can be used interchangeably.

Westphal et al.[177] identify three elements of technological capability: production, investment and innovation. Production refers to the capabilities of operating and maintaining existing technology and improving within the original design. Investment refers to capabilities that expand existing production capacity and duplicate it through new facilities. Innovation refers to capabilities that create new technology and also its implementation.

Lall[178] argues that when addressing technological capability one should consider factors that are firm-specific (i.e. firm-level technological capability), and others that are more general or country-specific (i.e. national technological capability). He then breaks down firm-level technological capability into functions and degrees of complexity. The major functions identified are categorised into investment, production and linkage capabilities.

Investment capabilities refer to skills required for pre-investment studies, facilities installation and commissioning. Production capabilities involve skills required for operational tasks (e.g. production, control, maintenance, adaptation, improvement, R&D, design, innovation). Linkage capabilities are those required to interact with the firm's external environment (e.g. suppliers, subcontractors, R&D institutions).

Functions evolve greater complexity in stages: from basic to higher; from skills required for simple tasks to skills required for complex tasks. It is worth mentioning that Lall's functions are neither exhaustive nor have to be performed internally by the firm.

With regard to national technological capability, Lall[179] suggests a broad framework that involves capabilities, literally encompassing physical investment, human capital and technological effort. In addition, he considers capability interactions with incentives that arise from market forces, institutional functioning and government policies. He includes the institutional framework (i.e. market and non-market institutions) as well, drawing on the idea that developing country backwardness is particularly due to an inappropriate institutional framework.

Variants of Lall's firm-level technological capability framework have been used as dictated by the research focus. Figueiredo,[180] for instance, uses a disaggregated framework made up of five technological functions and seven levels of capability (or complexity). Teece's[181] emphasis is on firm dynamic capability, arguing that learning is translated into continuous improvements through insertion of minor innovations, leading to new product development. He considers that a firm's ability to subscribe to such a dynamic depends essentially upon its organisational process (and some other factors, such as paths and markets).

2.5.2 The market perspective in building technological capability

Several factors impact on firms and tie them to the external environment. These factors are common, sometimes country-specific, and relate more to macro considerations. Lall[182] puts forward a framework that presents these ties from two perspectives: the demand and the supply perspective for building a firm's technological capability.

The demand perspective refers, first, to the inherent need for new knowledge in order to introduce new technology into firms. Second, it refers to how conducive the macroeconomic environment is (e.g. favourable trade regimes[183]) to firms investing in new technological capabilities. Third, it refers to technological change occurring in developed countries. This change incentivises or drives firms in developing countries to upgrade, sooner or later, their technological capabilities in order to resist competition, particularly firms that are highly exposed.

With regard to the supply perspective, several supply-oriented factors drive firms to build technological capabilities. Firm size fosters this need (e.g. large-scale production relying on complex technologies and skilled personnel).[184] Skilled labour market accessibility, knowledge market accessibility, and firms' organisational and managerial capabilities are other significant factors.[185]

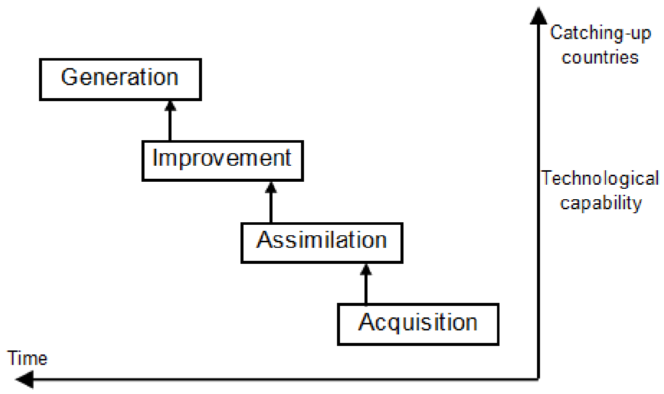
The market perspective is also used for explaining technology policy at country-level. Kim & Dahlman[186] identify three sets of market measures: (i) policies intended to create and foster market needs for the technology in question, known as demand side strengthening; (ii) policies intended to support science and technology capabilities, known as supply side strengthening; and (iii) policies intended to effectively link both the demand and supply sides.

This perspective highlights the limited benefits of policies intended to shore up the supply side without a competitive market, and the drag this places on investments in science and technology capabilities (deterrent effect on investment). For this reason, science and technology policies should be combined with industrial policies that structure the markets. It also underlines the limited benefits of policies intended to support the demand side (i.e. markets calling for more technology) when the supplier does not have the required capabilities to deliver the technology, which seems to be typical of developing countries. It accordingly highlights the importance of policies intended to effectively link demand to supply.

2.5.3 Technological change in developing countries

Technological capability in developing countries is very often built upon transferred technology. Kim[187] studies the phenomenon in rapidly industrialising countries, such as Korea. He explains that before generating their own technology (i.e. the innovation stage), firms in developing countries pass through three stages: acquisition, assimilation, and improvement (Figure 2-9), and orient their learning efforts accordingly (i.e. the learning effort can be oriented at country level through national or sectoral policy).

Figure 2-9: Kim's model of technological change in developing countries



Source: adapted from Linsu Kim, "Imitation to Innovation: The Dynamics of Korea's Technological Learning", Harvard Business School Press, 1997, page 88-91.

Kim argues that firms start building their technological capabilities by acquiring technology in the form of 'packages' from abroad. He emphasises the way of using this technology (via processes) to produce undifferentiated products, fairly similar to those produced elsewhere. From a technical perspective, an engineering effort is mainly required during this stage.

Experience during this initial implementation stage leads to some indigenous development activities aiming to produce differentiated products in order to resist market pressure. The pressure results from technology diffusion throughout the country, which brings new entrants and competition. This second stage is called ‘assimilation’, because through the assimilation of imported technology, indigenous firms could develop new products by directing engineering and development efforts, such as imitative reverse engineering (and other non-research efforts), to achieve ‘duplicative imitation’.

The following stage of this model is called ‘improvement’ as further assimilation efforts associated with increasing market pressure lead to technology ‘improvement’. For this to work, indigenous scientists and engineers should have the capacity to engineer, develop, and then research, in order to achieve ‘creative imitation’.

In explaining this model, Kim[188] stresses that firms in developed countries build their technological capability according to the following sequence: research, development, engineering. He then points out that unlike developed countries’, developing countries’ firms evolve according to the opposite sequence: engineering, development, research.

It is apt to note here that lines between engineering and development and between development and research are not clearly drawn in the literature. Therefore, in the context of the present thesis, engineering, development and research efforts are thought of as the required sequence to move along the capability-complexity continuum, corresponding to basic, intermediate, and advanced, respectively.[189]

2.6 Technology transfer

As mentioned earlier, technology transfer involves exogenous factors. The present section positions the discussion at the nexus between transferor and transferee.

Technologies transferred can be old (mature), established, or sophisticated (the latest or new).[190] Generally, reasons behind transferring technology are viewed differently by the suppliers (developed countries) and the acquirers (developing countries). Developing countries import technology because it is a less risky option, technically and financially, having already been used elsewhere, and since little R&D investment is required to quickly exploit it locally.

Developed countries, on the other hand, export technology because they seek to increase returns on R&D investment, or they consider that the transferred technology has been exploited up to its limits and can be transferred without any risk (e.g. fuelling future competition, security considerations), or the acquirer's capabilities are deemed to be not sufficiently advanced to make use of the relatively advanced technology transferred.[191]

2.6.1 Embodiment forms of transferred technology

The literature traditionally considers that technology transfer is likely to occur in embodied form.[192] Sharif[193] and Haines & Sharif[194] identify four components when considering technology transfer. Technoware (i.e. object-embodied technology) refers to the core elements of transferred technology (e.g. equipment, machinery, tools, and physical facilities). Humanware (i.e. person-embodied technology) refers to transferred personnel abilities to achieve transformation operations (e.g. skills, experience, wisdom). Infoware (i.e. document-embodied technology) refers to documentation transferred and used by individuals for learning (e.g. process specifications, procedures, theories, observations). Finally, Orgaware (i.e. institution-embodied technology) refers to managerial aspects (e.g. planning, organising, motivating) required for the integration of Technoware, Humanware and Infoware.

Minimum conditions are required to make effective use of these four components. Technoware needs operators; Humanware needs motivation; Infoware needs updating; and Orgaware needs evolution.[195] These four components interact dynamically and are required to manage simultaneously the transfer process. Indeed, Technoware is developed, installed, and operated by Humanware. Humanware is guided by Infoware. Infoware is enriched and updated by Humanware and Orgaware. Technoware, Humanware, and Infoware are brought together through Orgaware.

2.6.2 Technology transfer mechanisms/typologies

The objective of technology transfer is to serve the purpose of local technological capability-building, described in the literature as 'local' diffusion of technology. In order to achieve successful technology transfer in developing countries, a combination of mechanisms is used (e.g. licensing, sub-contracting, equipment and material supply, and consultancy).

Technology transfer can also be regarded as a three-element process comprised of transferor, transferee and linkages.[196] Linkages can be direct, such as licensing, personnel training abroad, and hiring of experts and contractors. They can also be indirect, such as equipment and material purchases, participation in international meetings and exhibitions, and publications (e.g. books, journals).

The UN Centre on Transnational Corporations[197] has put forward another technology transfer typology, commercial (e.g. foreign direct investment – FDI, joint ventures, licensing) and non-commercial (e.g. publications, foreign students, training). The use of FDI as a mechanism prevails in developing countries.[198]

Newly industrialised countries (NIC) have made use of unconventional mechanisms in acquiring high technology (e.g. electronics and computer industry). Countries like Japan, South Korea and Brazil used reverse engineering and product imitation to acquire technology. Taiwan, China and

South Korea, for instance, adopted the mechanism known as ‘reverse brain drain’ by attracting experienced expatriates from abroad and putting them in appropriate institutions or industries.

It is important to mention that whatever the mechanism used, technology transfer is greatly affected by industry-specific factors (e.g. products, facilities), region-specific factors (e.g. cultural considerations), country-specific factors (e.g. political and economic system), and organisation-specific factors (e.g. existing knowledge, management).[199]

The complexity that arises from the association of those factors with the available mechanisms makes clear that there is no one-size-fits-all solution for developing countries. Each country has to seek its own solution to technology transfer.[200]

2.6.3 Transferor-transferee relationships

Successful transfer is highly dependent on the strength of the linkages between the transferor and transferee. Indeed, building sound linkages is underpinned by the depth of the mutual understanding of the transferor and transferee’s interests, and the coordination between them. Transferor motives are often economic (business-oriented), possibly alloyed with some political considerations. Transferee motives, on the other hand, might be economic or non-economic, but often aim at building local capabilities for national developmental objectives. Mutual understanding may explain, for instance, why multinational corporations’ strategies are often in line with local economic firms’ objectives, but virtually always different from national developmental objectives.[201]

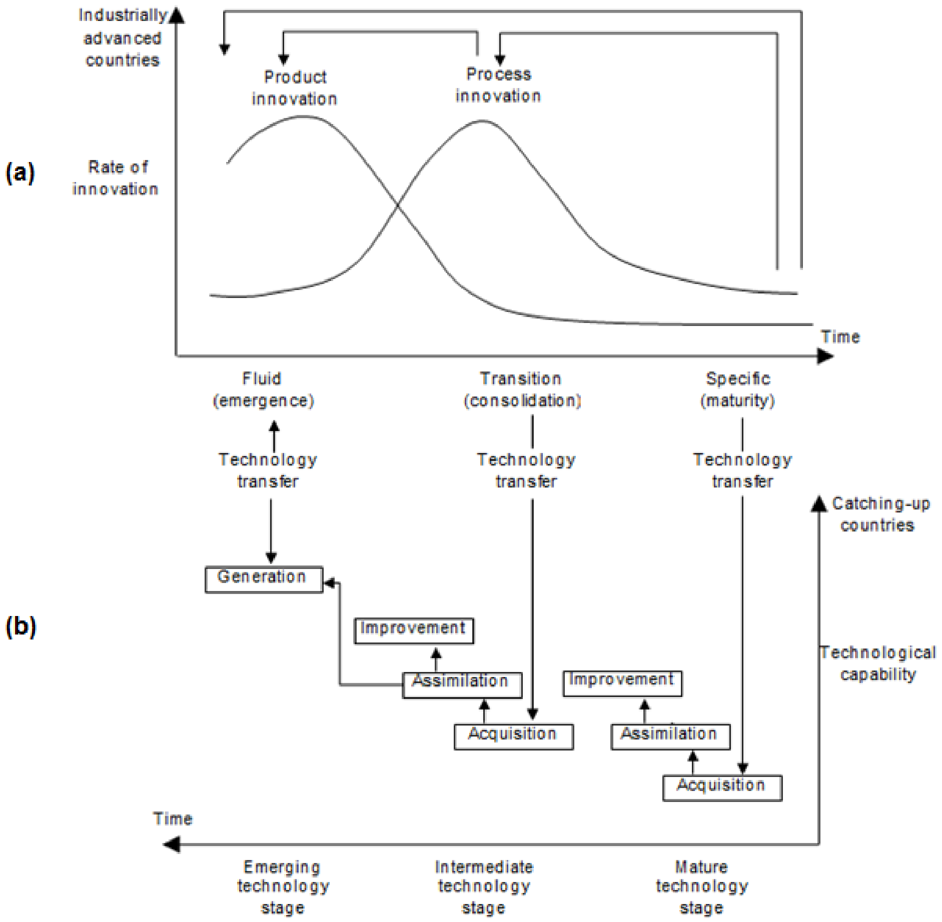
Mutual understanding is also a matter of negotiation balance and bargaining power. In general, developing countries have low bargaining power compared to developed countries because of several factors such as prior knowledge limitations, immature international experience, and imbalanced market structures (e.g. supplier markets).

In order to establish sound transferor-transferee linkages, Lee et al.[202] point out the need for the transferee to adapt technology transfer strategies in accordance with the technological development stage reached. Adaptation occurs by choosing suitable transfer mechanisms. These mechanisms depend on the transferee's technological capabilities and the technology life cycle. They in turn depend on the transferor's willingness to adhere to them, considering criteria such as technological novelty, the strategic importance of transferor activities, and further considerations like intellectual property protection.

Abernathy & Utterback[203] and Utterback[204] put forward a technology trajectory model illustrating the technology life cycle in developed countries (Figure 2-10a). It explains that technological change rate or innovation, for both products and processes, occurs over three main phases. The fluid phase represents the fluid pattern of innovation. During this formative period, the radical product innovation rate is higher than the incremental innovation rate, and firms are experimenting with new products and attempting to place them on the market. In the fluid stage, both products and markets are rapidly changing. Consequently, a firm's structure needs to remain flexible. Because of the high product innovation rate, less attention is paid to process innovation during this period. The fluid phase is followed by a transitional phase where product varieties converge towards a dominant design that may result from an increasing or dominant market share or regulation. As a consequence, firms direct their efforts towards improving the process of product manufacturing (e.g. procedures, cost); a high process innovation rate is then observed. The third phase is 'specific' as only some industries enter it. During this phase, products, processes, and markets mature, and firms focus on cost, volume and capacity. Innovation for both product and process occurs at a small incremental rate.

Kim[205] connects technological trajectories in developed (Figure 2-10a) and developing countries (Figure 2-10b). The idea is that the transferee who successfully acquires mature technology and assimilates it may shift to acquisition and then assimilation of more sophisticated (high) technology. The transfer process continues even when the transferee reaches the level of generating their own technology. Kim also argues that linkages are possible at several stages. Technology can then be transferred at the mature, transitional or fluid stage.

Figure 2-10: Kim's model of technology trajectory linkages



Source: adapted from Linsu Kim, "Imitation to Innovation: The Dynamics of Korea's Technological Learning", Harvard Business School Press, 1997, page 89.

Transfer success predominantly depends on the absorptive capacity of learners. Kim[206] argues that the intensity of organisational effort has a preponderant influence as compared to the influence of prior knowledge, particularly on long-term learning. This intensity is translated through actions of both continuous and discontinuous learning.

This is particularly true in today's ever-changing environment where knowledge does not necessarily accumulate and is not necessarily path-dependent.[207] For instance, Chen & Li-Hua[208] argue that when technology is at the embryonic stage in developed countries, firms in developing countries can seize the opportunity for leapfrogging (discontinuous change) through in-house R&D. Success depends on the availability of funds, talent, and government support. It also depends on self-innovation culture and abilities which require considerable time to build, without which leapfrogging opportunities are very hard to seize. As a result, some NICs have used other mechanisms, such as exercising a measure of control over host firms in developed countries (e.g. holding shares, market access) for, inter-alia, expediting self-innovation abilities.

Therefore, in addition to the knowledge-accumulation perspective, the knowledge non-accumulation perspective is relevant for understanding the transfer of high technology systems, such as satellites. A caveat here should be added: the above model is not applicable in all situations.[209] However, it is deemed useful in understanding the dynamics of satellite technology transfer and the appropriate strategy.

2.6.4 Cultural differences in technology transfer

Cultural difference is another potential impediment to sound linkages and mutual understanding between transferor and transferee. Culture is a collective phenomenon.[210] This concept is rarely monolithic and can only be characterised by certain heterogeneity.[211] Its nature can differ according to the level of aggregation (e.g. nations, organisations, or other collectives) and the particular cultural dimension.

In a technology transfer context, these factors are interwoven with others involved in the transfer process, such as knowledge types, absorptive capacity, language, geographical proximity and international experience.[212]

In view of this complexity, the present study is limited to examining management practices at an organisational level that shape a learning culture facilitating technology transfer. Some of the most influential practices are quality practice, training, management commitment, sharing/understanding (inter-personal social interaction) and team-based work.[213] Moreover, organisations which delegate responsibilities, tolerate creative mistakes, and provide slack time to work on new ideas, foster a learning culture. [214] Cross-cultural training programmes are another lever for overcoming cultural obstacles.[215]

2.7 Macro-environment: the technological innovation system approach

As discussed earlier, building technological capability through technology transfer is affected by a combination of factors at individual and team levels (micro level) as well as at organisational and firm levels (meso level) within the national, sectoral and international environment (macro level). The emphasis in this section is on the macro environment that can be explained from the literature using innovation system frameworks.

The concept of ‘innovation system’ was introduced by Lundvall.[216] It builds on evolutionary theory[217] and other theoretical considerations related to learning by interacting and institutional economics.[218] It refers to a system of actors and institutions whose interactions largely explain learning effectiveness and innovation. The idea is that in building capabilities, organisations or firms are not acting alone; they are linked to other actors and operating within contexts that influence their activities.

The analytical importance of the innovation system approach stems from the growing importance of knowledge in technological development, the growing number of actors and institutions generating this knowledge, and the growing adoption of systemic approaches in technological development.[219] Adopting this approach is in congruence with the present context of knowledge-intensive industry.

2.7.1 Concept versatility

The innovation system approach has been applied at national level. It refers to the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies.[220]

Malerba & Nelson[221] study the process of catching up for different sectoral systems in several countries. They claim that industries differ in both their catching up process and in the conditions surrounding this process. They point out the need to focus more on the dynamics of a sectoral innovation system rather than the national innovation system. Malerba & Nelson[222] argue that "While analyses of sectoral and national innovation systems share a perspective that multiple actors are involved, the national innovation system concept is more aggregative and is particularly oriented to broad national characteristics. In contrast, the sectoral innovation system concept is particularly concerned with highlighting sector-specific characteristics within the environment where development takes place".[223]

As with sectoral systems, the unit of analysis for the innovation system may be a particular technology. This context is referred to as a technological innovation system. Carlsson & Stankiewicz[224] define it as "a network of agents interacting in a specific economic/industrial area under a particular institutional infrastructure or set of infrastructures and involved in the generation, diffusion and utilisation of technology". [225] Technological innovation system boundaries may differ from national boundaries. They can coincide with local or regional areas. They can even be international or global according to agents' locations, capabilities and the relationships between them. Unlike national innovation systems, technological system frameworks are applied in less aggregative form, focusing on fewer macro considerations.[226]

2.7.2 Technological innovation system components

The building blocks of a technological system framework are actors, networks and institutions. Actors refer to organisations that can be gathered into four categories: suppliers and users (vertical linkages), universities and public research centres, financial organisations, government and related public policies. Actors create knowledge, influence institutions, as well as shape the perception of this technology.[227] Jacobsson et al.[228] call the most technically, financially, or politically powerful actors 'prime movers' or 'system builders', as they can strongly influence system development.

Actors are linked in synergistic "networks and clusters of innovation, production and distribution that integrate complementarities in knowledge, capabilities, and specialisation".[229] Interactions between actors can occur within market networks or non-market networks, locally or globally. In general, developing countries are deficient in terms of local networking (e.g. university-industry and research-industry linkages).[230] They are also disconnected from international actors (e.g. R&D, suppliers, and customers).[231]

The third technological system component that shapes networks and interactions between actors are institutions. They refer to laws, rules, standards, norms and practices governing interactions. They range from the most binding to the less binding, and from formal to informal. They can have a national effect or an effect on a specific sector or technology.[232] Institutional barriers faced by developing countries when transferring technology are often reflected through a lack of flexibility, cumbersome procedures,[233] and shortage in addressing intellectual property rights. [234]

In addition to the three traditional elements of a technological system, Malerba & Nelson[235] mention the 'knowledge base' as a fourth element. This is relevant as each sector has its own knowledge base. For instance, knowledge can be general (public), sector-specific and even firm-idiosyncratic. Knowledge can also be 'easily' transferable and difficult to diffuse.

2.7.3 Concept applicability in developing countries

In practical terms, this approach suggests the mapping of knowledge flows between actors, and evaluating channels and identifying bottlenecks in order to act appropriately. The mapping directs decision-maker attention to systemic failures rather than separate failures, such as market failures or lack of R&D funds. However, the proper application of this approach in developing countries may be hindered by a lack of mature data to compile statistical indicators of knowledge flow. Even when flow measurements exist, this approach presents significant challenges to translating them into performance indicators.[236]

In addition, multiple views exist of the appropriate analysis level (e.g. national, sectoral, regional, or local). This makes it difficult to adopt comparable approaches across units of analysis (e.g. countries, sectors, or regions). The dynamic interplay between levels of analysis increases difficulties. When it comes to applying the innovation system approach at country (or national) level, it is important to note that scholarly work reveal that national innovation systems in developing countries are not well developed.[237] They lack resources and capabilities to effectively collaborate and play a key role in the production of innovation.

2.8 Research Gap

The critical evaluation of the literature conducted in this chapter has covered major aspects of technological learning, technological capability-building, and technology transfer in developing countries.

A knowledge-based perspective has been adopted throughout the analysis and reveals that the literature remains highly influenced by a mono-dimensional economic perspective, backed up by technology-policy literature that also ties in closely with an economic perspective. Indeed, much of the literature builds on cases where the transferor’s economic (i.e. business-oriented) motives are in line with transferee economic motives. For instance, multinational corporations seeking economic opportunities (e.g. new markets, preferential production conditions) in developing countries through local firms that are also driven by economic objectives.

A challenge facing the author is to investigate the phenomenon where: (i) the transferor might not have engaged in as much international trade as larger firms (e.g. small companies and university spin-offs); and (ii) the transferee, unlike the transferor, is driven by non-economic and developmental goals such as those posed by government agencies (i.e. transferor and transferee objectives are not aligned).

Also, much of the evidence provided by the literature stems from studies related to mass-produced goods (e.g. assembly lines, steel mills, automobiles, electronics, and computers). The production process in the latter is key in the transfer, and the transferred knowledge is mainly explicit and relatively easy to analyse. However, the present thesis emphasises knowledge-intensive, complex, and one-off products, namely satellites. Design, systems engineering, and integration are crucial phases for their production. Tacit and integrative knowledge also have a vital role to play. Transfer is then relatively difficult to analyse. In this respect, even when the literature hints that complex technological activities are covered, detail on how the complexity is handled is not always provided and appropriately explained. A trend to “confuse apples with oranges” has been noted (i.e. simple and complex technologies analysed together).

Moreover, the literature focuses mainly on knowledge transfer evaluation either at the firm or national levels. It explains that causes of knowledge transfer failures can mostly be attributed to: (i) the lack of understanding that the process is slow, long and laborious; and to (ii) the inability to identify appropriate capabilities and ways to develop them. This raises the question as to whether conducting analysis at a more aggregative level, such as that of a firm or nation, captures change that occurs slowly, and furthermore, within a nascent and complex technological sector. Therefore, the present study includes less aggregative units of analysis (i.e. individual, team) in order to capture “micro” changes.

Two further “grey areas” have been noted from the critique of the literature. The first is the tendency towards focusing on exogenous factor evaluation (knowledge transferred from abroad) at the expense of endogenous factors (locally-built knowledge) required to effectively absorb foreign knowledge. In this respect, the present thesis pays more attention to the dynamics of transferee local effort and local learning. This is particularly relevant when the transferee is a government agency, motivated mainly by non-financial incentives (i.e. learning and local capability-building).

The second is the lack of clarity with regard to translating theories underpinning technological learning, technology transfer, technological capability-building, and innovation systems, into practical evaluation approaches. This indicates that there is no one-size-fits-all methodology. Therefore, the present thesis proposes a one-off approach that suits satellite capability-building in the context of developing countries. For this to happen, there is a need to review the sector-specific satellite literature, which is the purpose of the following chapter.

References and Notes

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Chapter 3: Satellite technology in developing countries

The previous chapter analysed relevant foundational theories and concepts dealing with technological capability-building in developing countries. Devising an analytical framework to evaluate satellite technological capability-building requires further analysis of satellite technology peculiarities in developing countries. This chapter sheds light on the satellite industry with an emphasis on Earth observation small satellites (section 3.1). The architecture of the latter is depicted and the philosophy underpinning small satellite development is discussed in section 3.2. Project life cycle and management structure are discussed in section 3.3. Given that one of the main barriers to entry into the satellite industry is technology complexity, matters related to satellite complexity are addressed in section 3.4.

Based on the above, section 3.5 identifies key success factors for developing small satellites. It categorises them into managerial challenges at individual, team, organisational, and inter-organisational (or external environment) levels. Section 3.6 analyses the few studies to be found in the literature about small satellite capability-building in developing countries. As the mechanism of collaborative small satellite projects is the most common form of technology transfer to developing countries (including Algeria), particular attention is paid to its analysis. Learning opportunities offered through such mechanisms to the transferee in developing countries are also addressed.

Finally, due to the immaturity of experiences related to collaborative projects carried out hitherto, section 3.7 provides insights into the South Korean model, the only experience that has gained in maturity. In addition, the early Indian satellite development path is also explored. Many lessons can be learnt from the latter, particularly with regard to the unfavourable conditions under which the satellite programme was launched, the centrality of the vision and the implementation strategies pursued.

3.1 Satellite industry

According to the Satellite Industry Association, the global space industry's revenues in 2015 were $325 billion and the satellite industry's share in the space industry represented 64% ($208 billion).[1] The satellite industry encompasses four major components, two of them are viewed as non-core components: satellite services and ground equipment. In 2015, they respectively represented 61.16% ($127.4 billion) and 28.27% ($58.8 billion) of the global satellite industry's revenues.[2] The two other components considered as being at the core of the space industrial base are satellite manufacturing (i.e. spacecraft and their subsystems) and the launch industry (i.e. launch vehicle manufacturing, launch subsystems, and launch services). In 2015, the former represented 7.96% ($16.6 billion) of the global satellite industry's revenues, while the latter represented 2.59% ($5.4 billion).[3]

Earth observation services revenues accounted for only 1.6% of global satellite services in 2015 ($127.4 billion) whereas the rest related to communication services.[4] The number of operational Earth observation satellites represents 14% of the total operational satellites (1381 satellites in orbit by the end of 2015), with 51% of the total operational satellites dedicated to communications, and 37% to commercial applications.[5]

With respect to satellite manufacturing, among the 202 spacecraft launched in 2015, 54% were for Earth observation missions.[6] However, they represent only 8% in terms of total revenues generated against 36% for communication satellites.[7] The bulk of these Earth observation satellites are very small and cheap (called CubeSats and representing less than 1% of the total value).[8] These figures clearly support the argument that Earth observation satellites are not the most commercially driven segment in the satellite industry.

3.1.1 Earth observation small satellite industry

Euroconsult predicts that over 400 Earth observation satellites (civil and commercial, excluding very small satellites whose weight is less than 50kg) are expected to be manufactured between 2014 and 2024.[9] Expected manufacturing revenues are about $39 billion over the coming decade.[10] Over 40 countries are expected to order, build, and/or launch Earth observation satellites.[11]

Currently, Earth observation systems generate modest profits and are predominately funded by government. However, whilst most of these systems are expected to be small and "cheap",[12] the expected growth justifies today's presence of manufacturers in this market.[13]

This small satellite dynamic is of concern to traditional market players. The market is dominated by large firms (oligopolistic). Their concentration has discouraged competition (because of the highly risk-averse nature of the satellite industry) and affected the rate of innovation in the satellite industry. The latter has been much slower than in comparable high-tech industries (e.g. mobile devices, computers, and consumer electronics).[14]

Petroni & Santini[15] argue that large firms have perceived the emergence of small firms manufacturing small satellites as both a threat and an opportunity. In addressing the threat, they have started buying out the small firms. They view small firm-specific knowledge and innovative capability as an asset that can better position them to assume control over this growing market.

Other trends in this market are also plausible. Meurer & Seah[16] argue that a tendency towards resource diminution is leading manufacturers to devise new approaches to doing business. Competitors are joining forces throughout the value chain segments (e.g. sharing their hardware manufacturing facilities, satellite image distribution channels). Petroni & Santini[17] explain that, in addition, manufacturers generally tap other opportunities in "close-by" market segments, seeking to diversify their activities and strengthen their position in the small satellite market.[18]

Such approaches are lowering barriers to entry for new actors, particularly in the current climate of increasing geographical fragmentation of space activities across the world and between actors. However, those actors need business agility and interactivity. [19]

3.1.2 Satellite industrial supply chain

The broader space economy chain is composed of three main segments:[20] the space/satellite manufacturing supply chain; services from satellite operators; and actors providing consumer services (downstream activities). Even though those actors are not always thought of as part of the space community, they still provide services based on space assets.[21] In general, well-established downstream activities reflect developed space manufacturing activities.[22]

The space/satellite manufacturing supply chain is typically divided into five levels (primes, and four tiers) (Table 3-1). Primes refer to actors in charge of the design and assembly of the complete spacecraft system. The latter is then delivered to the users. In a technology transfer project with developing countries, the transferee usually deals essentially with the primes.

Table 3-1: Space/satellite industry supply chain

Positioning		Actors
Space manufacturing supply chain	Tiers 3 and 4	Scientific and engineering consulting
		Material and components suppliers
	Tiers 1 and 2	Designer and manufacturer of space equipment and subsystems
	Primes	Space systems Integrators/ full systems supplier
Services from satellite operators	Operators	Space systems operators
		Ground system operators.
Consumer services	Downstream	Devices and equipment supporting the consumer markets
		Space-related services and products for consumers

Source: adapted from OECD, 2014. The Space Economy at a Glance 2014. OECD Report, p.21.

“Tier 1” actors are those who participate in the design, assembly and manufacture of major subsystems such as the satellite platform structure, data-handling subsystem, power subsystem, communication subsystem, etc. “Tier 2” refers to actors which manufacture equipment to be assembled in major subsystems. “Tiers 3 and 4” cover producers of components and sub-assemblies. They usually specialise in the production of particular electronic, electrical, or electromechanical components, or the production of particular materials such as cables and switches. "Tiers 3 and 4" also refer to scientific and engineering service providers, such as engineering firms, R&D organisations and universities. Scientific and engineering service providers can either be specialists or generalists. One should recognise that division between these levels is sometimes blurred because of task overlap.

Traditional satellite manufacturers often share elements of their supply chain with the automotive, electronics, aeronautics and defence industry.[23] With respect to the small satellite industry, the few small companies that have achieved a certain stability in this industry are highly vertically integrated.[24]

The space sector is not a "business like others".[25] Everywhere in the world, the vitality of its value chain hinges heavily on government contributions. Government is the main financier of public R&D and the major customer of space products and services, because of the highly risk-averse nature of this industry.[26] The dependence on government support seems greater in the Earth observation small satellite industry because its community is still closely tied to universities and R&D activities, and its market is not yet well developed.[27]

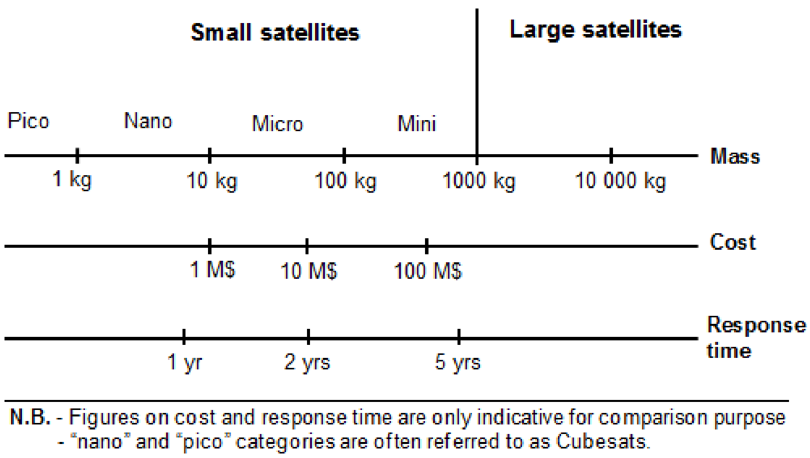
In developed countries, private contribution is significant throughout all supply chain stages. In developing countries, however, the chain is dominated by government actors (e.g. the Indian Space Research Organisation - ISRO). In general, a well-established supply chain reflects the value produced by the space industry. Building a local space supply chain is largely down to interactions between actors (or organisations) involved in the chain. From a knowledge-oriented perspective, the intensity of inter-organisational learning is reflective of the vitality of the space value chain, or the space innovation system.[28]

Satellite technology is thought of as a complex technology (see section 3.4). In this sense, the density and continuity of interactions have proved insufficient. Baldwin[29] claims that the technical architecture of complex systems matters in shaping the strategy of the organisation and whether parts of the system are insourced or outsourced. Based on modularity theory, [30] Baldwin claims that the knowledge flow between an organisation and its suppliers is influenced by the system architecture (architectural knowledge) and particularly by how loose (or strong) the coupling between its components (component knowledge) is. It is less complicated to outsource production when the coupling is loose, whereas production is often insourced when the coupling is strong.

3.2 Small satellite: concept and philosophy

In the context of the present thesis, small satellites are small Earth-orbiting artificial bodies operated remotely to collect information on the Earth; hence the name ‘Earth observation small satellite’ or ‘remote sensing small satellite’. What, then, is small? As illustrated in Figure 3-1, the smallness refers to a category of satellites weighting less that 1000Kg. They are usually less expensive and of lower performance than large satellites.

Figure 3-1: Satellite categorisation



Source: adapted from the International Academy of Astronautics categorisation, second reference in Sandau, R., 2010. Status and trends of small satellite missions for Earth observation. Acta Astronautica 66(1-2), 1-12.

Sandau[31] explains that small satellites usually refer to satellites of reduced complexity. The concept implies faster knowledge diffusion and greater industry involvement, particularly local and small-scale industry.[32] With regard to Earth observation small satellites, Sandau summarises their mission through seven categories (Table 3-2). The last three categories are particularly relevant to small countries as they aim to develop local expertise in satellite technology.

Table 3-2: Earth observation small satellite missions

Mission nature	Mission objective
Commercial	A profit to be made from satellite data or services
Scientific/Military	New scientific/military data to be obtained
New technology	Developing or demonstrating a new level of technology
Competency demonstration	Developing and demonstrating a space systems competency
Space technology transfer/training	Space conversion of already competent engineering teams
Engineering competency growth	Developing engineering competence using space as a motivation
Education	Personal growth of students via course projects or team project participation.

Source: adapted from Sandau, Rainer., "Status and trends of small satellite missions for Earth observation", Acta Astronautica, Jan-Feb, 2010, 66 1-2, p1-p12.

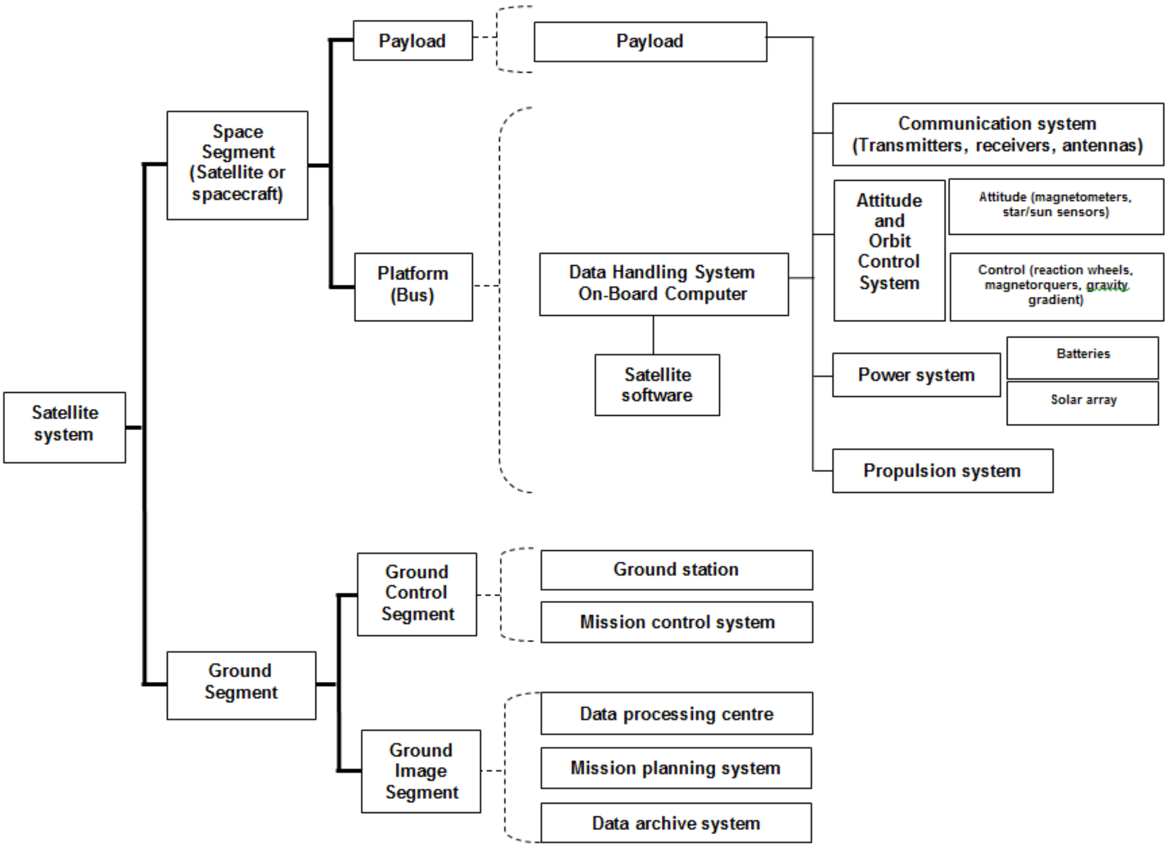
3.2.1 Earth-observation small satellite architecture

The typical small satellite architecture used in the present study derives from the literature on Earth observation small satellite architectures, including satellites developed for Algeria.[33] In general, small satellite can be divided into a ground segment and space segment (Figure 3-2). The ground segment refers to the components used to operate the satellite once in orbit, and to receive and process data (satellite images). The space segment refers to the satellite itself. The satellite is made up of a platform which carries one or several payloads. The payload consists of optical instrumentation (e.g. camera) and related modules used to capture images (e.g. control and processing electronics).

The platform provides services through the following subsystems: (i) data handling system or on-board computer (OBC), linked to the majority of satellite subsystems; the OBC has the capability to manage satellite operations to complete the objectives of the mission; (ii) attitude and orbit control system (AOCS), consisting of attitude (position and behaviour) modules allowing the attitude of the satellite to be determined and actively controlled; (iii) power system capable of generating, storing and managing the power needed for mission operations; (iv) propulsion system used to move the satellite; and (v) communication system used to communicate with the ground station.

In addition to the above-mentioned components, it is generally accepted that the ground support equipment is part of the space segment. This includes all electrical, mechanical and software items used to support assembly, integration and testing of the platform and payload. Typically, this includes a set of mechanical ground support equipment (MGSE) and electrical ground support equipment (EGSE) that is similar or identical to that of the actual ground segment used to test the satellite (e.g. communication system, power system and attitude control system).

Figure 3-2: Satellite architecture



Source: Author

3.2.2 Small satellite philosophy

The Department of Electric Power at the University of Surrey can be credited with the emergence of the small satellite concept through the development of the first successful small satellite in 1981.[34] This initiative was then emulated by many research organisations in the USA. It has shaped the well-known Faster, Better, Cheaper (FBC) approach for project management adopted by NASA in the early 1990s.[35] According to Fleeter,[36] the international space community considers that FBC principles underpin small satellite development.

FBC principles can be summarised as a new, innovative way of managing satellite projects. Effective innovative solutions (referred to as Better solutions) are developed and implemented in significantly shorter timelines (referred to as Faster) and with lower costs (referred to as Cheaper).[37] Watzin[38] explains that such approaches focus on “competence, empowerment with responsibility, freedom to innovate outside the established norms, and constant situational awareness”. [39]

Definition and acceptance of reasonable risk is another enabling principle of the FBC approach. Indeed, for a successful FBC mission, a trade-off between Faster, Better and Cheaper dimensions has to be found. Failure will primarily be the result of too much emphasis on cost and schedule reduction at the expense of appropriate risk management as risk reaches unacceptable levels.[40] Dornheim[41] argues that failure in this approach is predictable, as missions that “crossed into an area of high complexity and low development time, inevitably failed”. [42] In addition to the negative consequences of too much cost and schedule pressure, Dornheim points out that “loss or impaired performance [of the mission] is often found to be the result of mismanagement or miscommunication”.[43]

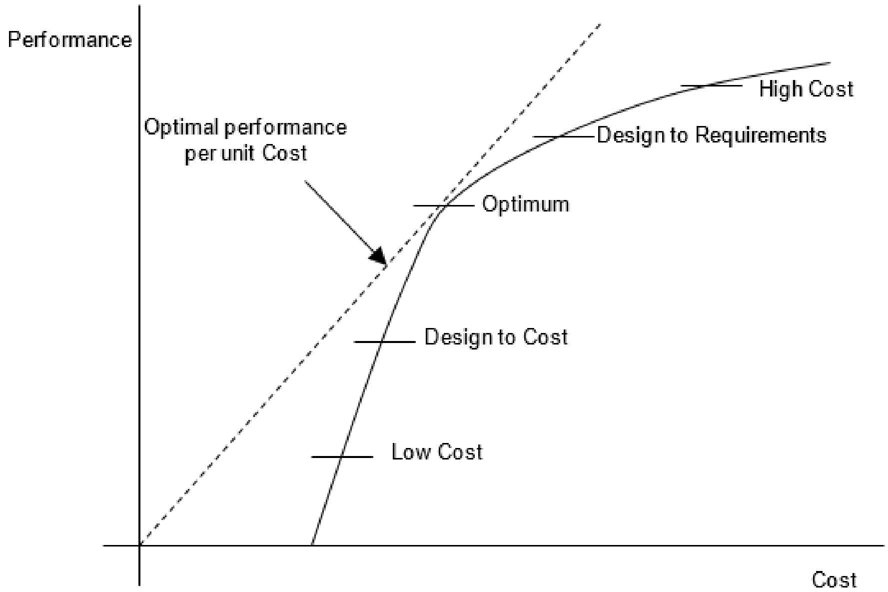
Dillon & Madsen[44] reject the emphasis put on success versus failure when evaluating the FBC approach. They suggest that there is a need to consider the benefit in terms of learning even when failure occurs. Dillon & Madsen argue that this approach produces knowledge at a lower cost than have traditional approaches – through setting stretch goals, or extreme goals. They claim that adopting extreme goals may have significant benefits in terms of learning (see chapter 2, section 2.4) even after the goals are abandoned. According to Ward,[45] these hidden benefits can be measured by adopting another evaluation framework based on the idea that “success-per-dollar is a more meaningful measurement of achievement than success per-attempt … The important thing is not how much success we get out of 100 tries, but rather, how much success we get out of 100 dollars”.[46]

The small satellite philosophy partly overlaps with the traditional way of developing satellites, where technological change is continuous (incremental innovation) (see chapter 2, subsections 2.5.3 and 2.6.3). Because of the highly risk-averse nature of this industry,[47] technologies (or components) used in small satellite development may already have an established pedigree or heritage in space usage.[48] Their adoption may result from conservative design. This is why technological change (rate of innovation) in this industry has been much slower than in comparable high-tech industries (e.g. mobile devices, computers, and consumer electronics).

In sum, the small satellite philosophy is anchored in both the traditional approach, where technological change is continuous (incremental innovation), as well as the radical innovation approach, or discontinuous change (e.g. new technology, new management philosophy) (see chapter 2, subsections 2.5.3 and 2.6.3). The approaches are combined with a view to managing the difficult balance between schedule, performance and cost.

In order to understand the logic underpinning this balance, Wertz & Larson[49] explain that cost and performance traditionally evolve according to a logarithmic curve (Figure 3-3). At the lower part of the curve, small additional resources (cost) will significantly improve performance, whereas in the upper part, large additional resources will only impact modestly on performance. The minimum of acceptable performance is achieved with a ‘low cost’ level. ‘Design to cost’ allows flexibility in terms of performance according to the available budget. The 'optimum' level refers to the perfect match between required performance and budget. Elsewhere, performance prevails over cost. In 'design to requirements', a required performance should be reached. In the 'high cost' approach, performance sought should be the best available (state-of-the-art technology).

Figure 3-3: Performance vs Cost relationships



Source: adapted from Wertz, JR., Larson, WJ., (Eds.), 1999. Space Mission Analysis and Design. Space Technology Library 8. Third Edition, Microcosm Press, p.248. And from Wertz, JR., Larson, WL., (Eds.), 1996. Reducing Space Mission Cost. Space Technology Library 6. Microcosm Press. Second reference in Moody, JB., 2004. The importance of Complex Product Systems to space Industry in Australia: A small satellite case study. PhD Thesis, The Australian National University, p.122.

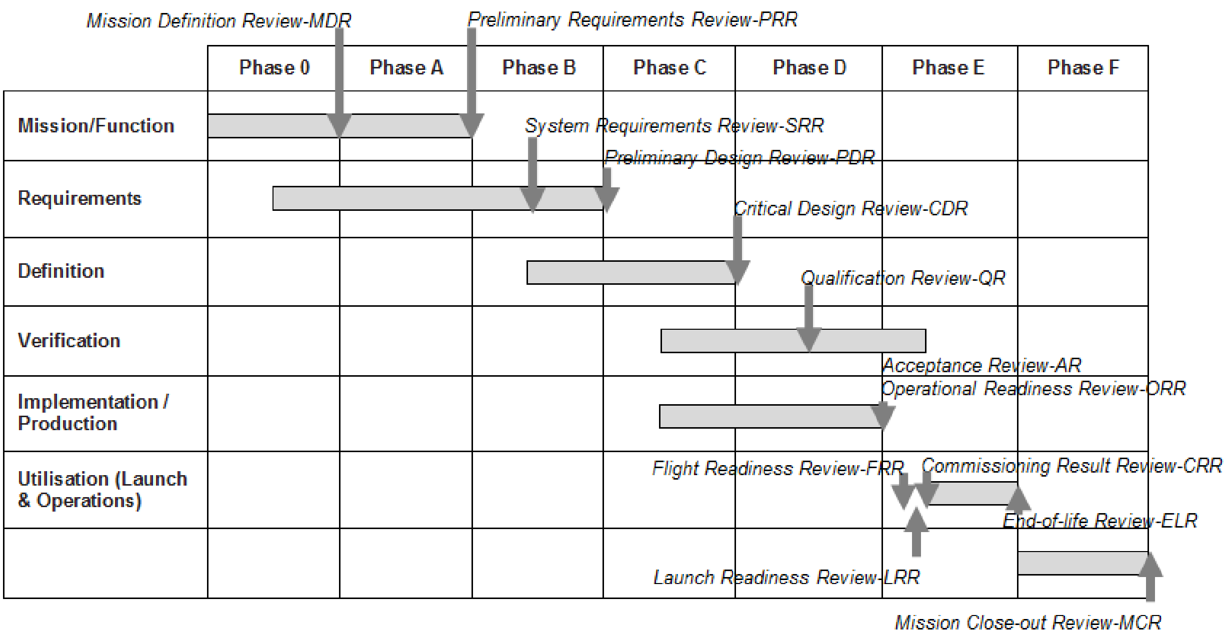
3.3 Small satellite project management

3.3.1 Project life cycle

Satellite projects are conducted through a number of phases. Each phase has a prevailing activity, and the transition from one phase to another is marked by a review. The latter has to attest to the successful completion of the previous phase and the readiness to start the next phase (as part of risk management).

A satellite project life cycle is typically composed of the following phases (Figure 3-4): phase 0: mission analysis/needs identification; phase A: feasibility; phase B: preliminary definition; phase C: detailed definition; phase D: manufacturing, assembly and testing; phase E: launch and operation of the system; and phase F: disposal (customer disposal).

Figure 3-4: Typical project phases and reviews

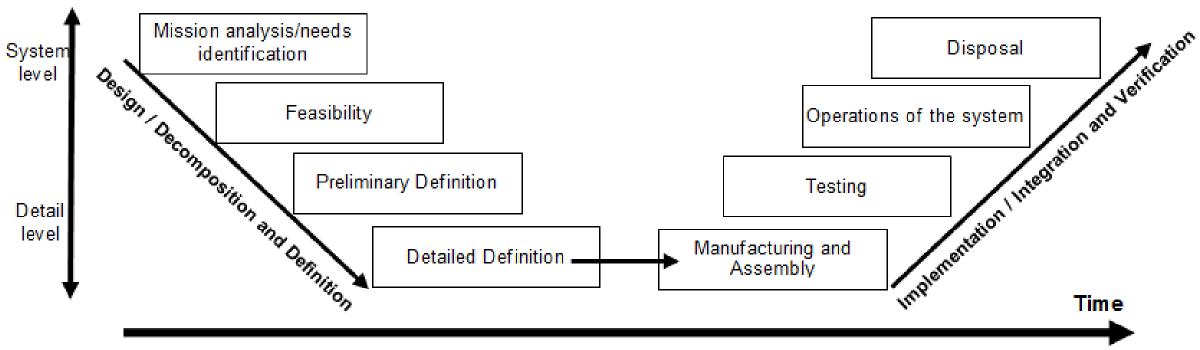


Source: adapted from ECSS, 2009. Space project management: Project planning and implementation. European Cooperation for Space Standardisation, ECSS-M-ST-10C Rev. 1, pp.19-20.

Forsberg & Mooz[50] illustrate the overall evolution of space system design and implementation (Figure 3-5) as a V-shaped process. The design is a top-down process, whereas the implementation is a bottom-up process. During the design (i.e. top-down) process, a large multi-disciplinary team of engineers creates satellite models using specialised tools and software. The process is based on intense dialogue between the prime constructor and both the customer and the suppliers – to refine needs and technical specifications. In general, small satellites are seen as one-off products. However, they are often designed quickly (in approximately 1 to 3 years), as they rely on previous designs and components.

During the implementation (i.e. bottom-up) process, a separate team of technicians implements the design produced by the engineering team. As the satellite will be employed in a harsh extra-terrestrial environment, it has to be rigorously tested (including its components) over months throughout the implementation phases. These tests are crucial, and some of them require specific and often expensive equipment and facilities (e.g. chambers for testing satellite behaviour under extreme space-like temperatures and pressures and vibration equipment for testing satellite structure). In general, for small satellite projects, approximately 50 to 100 people (involved in engineering, technical and managerial tasks) are required to complete a project, as opposed to hundreds of people for large satellite projects.

Figure 3-5: The V-Process of satellite design and implementation



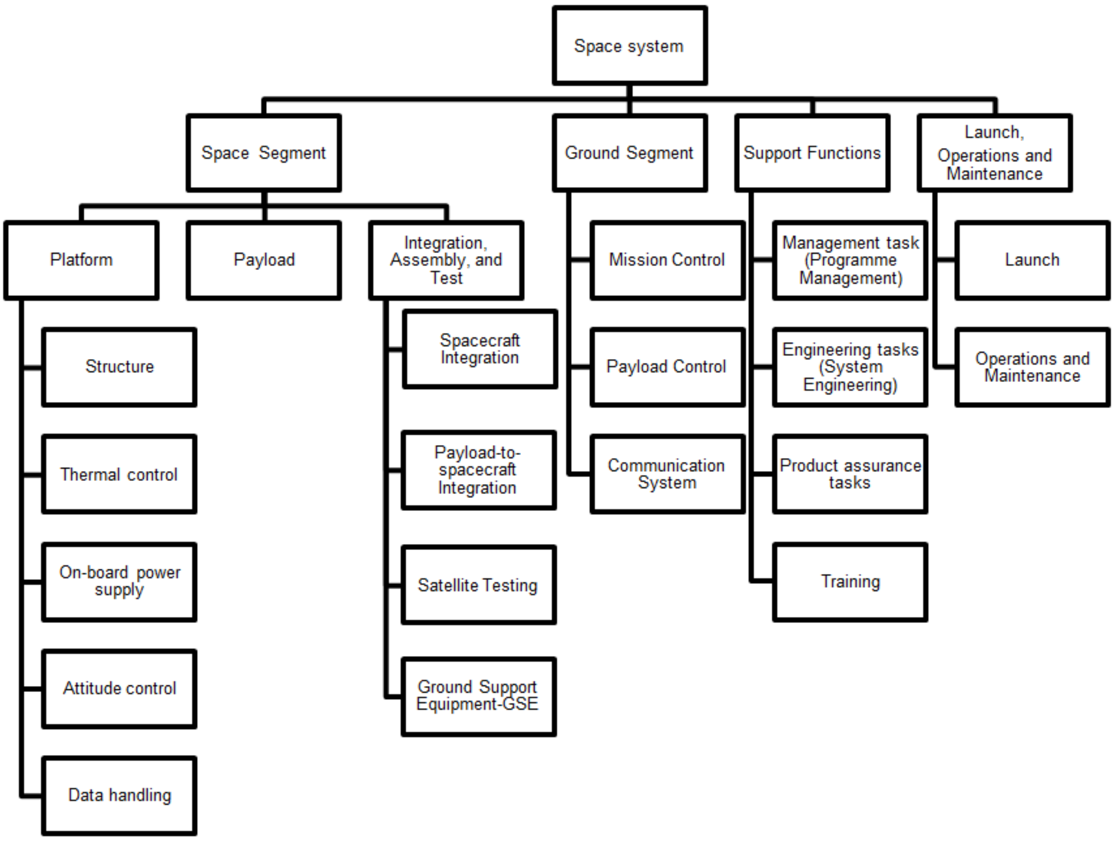
Source: Author. The model is the author's combination of models presented in: Forsberg, K., Mooz, H., 1999. System Engineering for Faster, Cheaper, Better. INCOSE International Symposium 9(1), pp.924–932. Aguirre, MA., 2013. Introduction to Space Systems: Design and Synthesis. Space Technology Library, Springer, p.12. ECSS, 2009. Space project management: Project planning and implementation. European Cooperation for Space Standardisation, ECSS-M-ST-10C Rev. 1, pp.19-20.

Aguirre[51] stresses that the upper part of the "Vee" relates more to the aggregated aspects of the system (i.e. system level in Figure 3-5) involving few engineers, while the lower part refers more to disaggregated aspects (i.e. detail level in Figure 3-5) involving larger teams. According to ECSS,[52] the top-down process starts from the Preliminary Requirements Review (PRR) to the Preliminary Design Review (PDR). The bottom-up process starts from the Critical Design Review (CDR) to the Acceptance Review (AR). The time between the PDR and the CDR is used for equipment procurement and development. Any procured (e.g. off-the-shelf) or manufactured item should undergo its own development cycle, starting from the requirements definition on to integration into an upper level (e.g. unit, subsystem, system).

3.3.2 Project management structure

A space system project is a combination of technical and support functions. Technical functions are those related to technical tasks during the design, development and testing of the space and ground segments, along with their components. The support functions refer to management, system engineering and product assurance tasks. The commonly accepted approach is to divide space projects into manageable work packages according to task nature, as illustrated in Figure 3-6. A Work Breakdown Structure (WBS) is used as a framework to identify the components of the space system, their relationship to one another, support functions and associated services (e.g. test facilities). Typically, each function represented in the WBS is reflected by an organisational entity (e.g. department) within the organisation. Systems engineering and programme management are often functions referring to groups coordinating satellite development. The WBS shown in Figure 3-6 illustrates work packages performed at the system level. However, this framework can be used at lower levels of aggregation.

Figure 3-6: Example of a satellite Work Breakdown Structure



Source: adapted from ECSS, 2009. Space project management: Project planning and implementation. European Cooperation for Space Standardisation, ECSS-M-ST-10C Rev. 1, pp.17-18. Fox, B., Brancato, K., Alkire, B., 2008. Guidelines and Metrics for Assessing Space System Cost Estimates. Technical Report, RAND Project Air Force, pp.152,153, 189. Abramson, RL., Bearden, DA., Glackin, DL., 1995. Small Satellites: Cost Methodologies and Remote Sensing Issues. Proceedings SPIE 2583, Advanced and Next-Generation Satellites, 548-564.

3.4 Satellite technology complexity

Complexity is one of the main barriers to entering an advanced and high technology industry. Successful transfer of high technology requires the transferee to learn how to effectively manage this complexity; hence, the importance of this section. The Technology Atlas Team[53] argues that interaction complexity between the four technology components proposed by Sharif[54] (Technoware, Humanware, Infoware, and Orgaware) increases in relation to technology sophistication (see chapter 2, subsection 2.6.1). The sophistication may result from an increase in operational complexity (Technoware), advanced skills and experience (Humanware), documentation value (Infoware), or advanced managerial practices (Orgaware).

The Technology Atlas Team cautions that unlike the Technoware component, which can be brought from abroad, the other components cannot be imported easily. They depend heavily on local or indigenous considerations. Humanware hinges on local technological learning effort. Foreign Orgaware needs a considerable adaptive effort, particularly in the local context of developing countries. Transferred Infoware very often does not go beyond basic documentation.[55] Moreover, as technology transfer is a long and progressive process, transfer effectiveness also depends on the local assimilation rate of imported technology. The rate has to be rapid enough to set in place local capabilities that will assimilate the next 'higher' generation of imported technology.[56]

Complexity is therefore seen as a socio-cultural phenomenon reflecting interactions between products, processes and organisations.[57] From this standpoint, a group of scholars led by Hobday & Rush[58] recognised the peculiarities of certain technological activities featured by complexity. They laid down a number of principles for a new holistic approach towards complex products or systems called Complex Product Systems (CoPS). It goes beyond a purely technical perception and includes managerial and political considerations. Hobday defines CoPS as "high cost, engineering-intensive products, systems, networks and constructs".[59] He also explains that CoPS are often produced "in one-off projects (or small batches) and the emphasis of production is on design, project management, systems engineering and systems integration".[60] Complexity mainly stems from: (i) the number of components that are customised to fit in the products/systems; (ii) knowledge and skill diversity required for production; and (iii) new knowledge required for production. [61] Put differently, the complexity of any system derives from the complexity of knowledge required to build its components and the knowledge required to put together these components to form a system.

Davies[62] and Hobday[63] put forward categories of products that might fall into CoPS. They explain that stand-alone products, such as satellites, which refer to systems made up of interconnected components, can be considered as CoPS. Consequently, a CoPS framework has been used in analysing satellite projects. Moody & Dodgson[64] draw heavily on the CoPS approach to analyse a small satellite collaborative project in Australia. Wood[65] considers the managerial challenges related to a CoPS project in exploring technological capability-building within satellite programmes in developing countries.

In reality, product complexity spans a continuum that ranges from low complexity products, referred to as simpler mass-produced goods, to more complex products referred to as CoPS.[66] Therefore, it is essential not to restrict the analysis of complex products by only using dedicated analytical tools. Conventional analytical tools, initially devised for mass-production analysis (e.g. Abernathy-Utterback's model, see chapter 2, section 2.6.2), can also bring valuable insights.

3.5 "Successful" management of small satellite development

Small satellites can be seen as either CoPS or systems developed under the FBC philosophy. The present section explores both perspectives and identifies key success factors for developing small satellites.

According to Hobday & Rush,[67] managerial challenges to the successful development of small satellites can be categorised into: (i) challenges at individual and team level, dependent upon the control of the project (or the system integrator); (ii) challenges at organisational level, dependent on both the control of the project and the organisation; and (iii) managerial challenges that are outside the control of the project, dependent on the organisation and the external environment (i.e. relationships with partners and customers, the business environment).

Hobday & Rush[68] stress that priority should be given to fostering an ability to solve problems internally (within the project). Such an ability provides better negotiating capacity in resolving problems, subject partly to control of the project, and consequently offers increased flexibility in managing external situations that are out of control.

3.5.1 Managerial challenges at individual and team level

Small satellite development projects rely heavily on team work rather than institutional or organisational processes. Successful FBC projects are those where the team leads the development and not the institution. Watzin describes this kind of development as "a team-driven process, not a process-driven team".[69] A successful team-driven process hinges upon self-motivated team members, their talents, technical competencies and communication skills. Continuous and strong interactions should connect the team-lead researcher (or principal investigator) to his team members so that trade-offs that need to be made do not endanger project outcomes and remain consistent with resource limitations.[70] Co-location of team members naturally increases formal and informal communication. Teams insulated from day-to-day operations have proven to be more efficient.[71] Peer reviews have always proved to be more valuable than formal reviews.[72]

The project management function should be balanced and agile. It should focus more on motivating the team, providing guidance on the planning and business aspects of the project, encouraging and facilitating communication development, and coordinating it, rather than focusing on technical development. The latter is more a responsibility of the system engineering function, which remains a complementary function of management.[73]

The system engineering function should be strong enough to lead effectively and in a timely manner the technical development and to make technical trade-offs between subsystems (i.e. at the horizontal level) and amongst levels of decomposition/integration (i.e. at the vertical level). System engineering activities are carried out by an organisational entity within the project team and across the project life cycle.[74]

The system engineering approach should be systemic.[75] Each subsystem lead engineer should develop a mission level perspective rather than a limited, personal subsystem vision. A subsystem lead engineer with a mission level perspective can easily be empowered to make decisions within their area of responsibility. Effective decision making distribution is enabled through a clear project structure, a jointly developed schedule, technical requirements and technical interfaces (e.g. standardised interfaces). Decisions should be taken, or driven, from the lowest possible level of the project structure.

Besides lead engineer prerequisites, the principal investigator must have an effective sense of 'the work at hand' or practical knowledge or experience (e.g. subtle trades) required to integrate, assemble or build hardware. In this regard, 'pure' theoreticians often lack a sense of practical appreciation.[76]

Minimal documentation is another common practice in successful projects. It aims to document only when value is added and when the documentation is required for communication (e.g. system requirements, specifications, interfaces, implementation plans and procedures).[77]

Project monitoring should be dynamically managed (i.e. with a real time system for monitoring). [78] Team members should be aware of the impact of any deviation or separate action on the overall project. Simple tools that are accepted by all members should be used for managing the project. In order to ensure dynamism and efficiency, experienced personnel, selected beforehand, are often appointed to key areas of the project. [79]

Managing risk is crucial in small satellite projects. Simplicity should be adopted as a design strategy.[80] Indeed, system testing, cost and scheduling induced by additional engineering and testing effort usually rise exponentially when complexity increases.[81] Small satellites also take advantage of modern technologies that are reasonably mature,[82] as well as extensively tested off-the-shelf technologies.[83]

Satellite team performance and productivity should strive for continuous improvement. This is enabled by effective group learning (see chapter 2, subsection 2.4.2). The latter is achieved through learning routines put in place and a learning culture encouraged. One of the enabling practices is to recognise the importance of tacit knowledge (see chapter 2, subsection 2.4.1), by identifying it, along with pinpointing individuals who hold it, and giving recognition to their work. Performance and experience should be rewarded. This is possible through incentivising experienced persons to share their knowledge with the less experienced (mentoring them so as to convey tacit knowledge particularly), and by incentivising the latter to learn from the more experienced.[84]

Another practice that should be encouraged is to keep good records on project progress during the project, with the intention of reusing them on future projects. This can be implemented by recording the lessons learned at the end of each major task or milestone.

3.5.2 Managerial challenges at organisational level

The organisation should build organisation-team confidence that enables project team empowerment. Confidence is built progressively by supporting the team without micro-managing it. For effective and efficient support, the organisation should place a high priority on organisation-team communication. It should remain continuously attentive to team requirements. Good organisation responsiveness is possible through the *a priori* assembling of a reservoir of resources that the team may need. This is particularly relevant in the context of a technology transfer project where transferee exposure time to technology (or the transferor's) is limited. Resources may be human, equipment, facilities, information or managerial knowledge.[85] The team's ability to call upon resources whenever needed rather than loading up with extra resources from the project's outset, and through its phases, is crucial in small satellite projects.[86]

A distinction should also be made between effective organisation-team communication and excessive reviewing that may lead to micromanagement. A hybrid communication approach appears to be the most appropriate way in this context.[87]

The organisation should rely on structured formal reviews to get insights on project progress (e.g. schedule, cost and impediments).[88] These reviews are at the same time self-evaluation landmarks for the project team. Unstructured reviews are also used.[89] They are deliberately unstructured to allow anyone in the project team, or the organisation management, to raise whatever question or concern it is deemed necessary to consider during the project. This kind of interactive review gives the organisation deeper understanding of the nature of the project, the context, individual profiles, strengths and weaknesses, as well as a measure of previous management actions and guidance for future actions.

Casual meetings and visits should also be encouraged.[90] They allow discussion on issues that are not directly linked to the project's sphere of influence, but may affect its conduct. They allow for progress monitoring and gauging the impact of decisions *in situ*, and all other aspects that are not addressed in other reviews. They reinforce confidence between an organisation's management and the project team.

Improving organisational learning (see chapter 2, subsection 2.4.2) by embedding best practices and new knowledge from project to project is another managerial capability that has to be developed. Learning difficulty derives mainly from the provisional nature of a project-based entity, which involves multiple actors often belonging to several functional and organisational structures. It is difficult for a provisional project-based entity to act as a knowledge "silo" like traditional organisational entities (e.g. departments). In the latter, people belong to the same entity and knowledge accumulates within it. Group and organisational learning can also be affected by some strategies that may cause staff reduction or re-organisation (experienced personnel quit the organisation or are posted to unrelated domains), all leading to loss in project and organisational memory.[91] Consequently, organic[92] management systems should be implemented. They allow flexibility by continuously adjusting individual and group tasks during the project and improving interaction between groups in both vertical and lateral directions, irrespective of their specialisations and hierarchical positions.

The organisation should build an open learning culture. It should recognise that learning is not “free”, and resources should be made available for that purpose (personnel, organisation, infrastructure, equipment, budget and time). It should understand that the benefits of learning are often perceptible in the medium- and long-term, but seldom in the short-term.[93]

The organisation should encourage the use of new knowledge and view the associated risk (e.g. mistakes) as part of the learning process. Clear guidelines and simple tools of risk assessment should be defined and accessible for all parties. The organisation should adopt simple tools and systems for helping groups work together. The organisation should conduct post-project workshops that can diffuse knowledge and contribute in making it organisational.[94]

In the particular context of governmental procurement in developing countries, there is a need for organisations to implement quality assurance approaches (e.g. continuous improvement). These relax or eliminate bureaucratic procedures, streamline acquisition contract execution, and allow more flexibility in the project.[95]

3.5.3 Managerial challenges related to the external environment

In the development of satellites, organisations are not acting alone, they are linked to other organisations and operating within contexts that influence their activities. Interactions with these organisations largely explain learning effectiveness and innovation.[96] In a technology transfer context, learning effectiveness is reflected by the local value created, particularly, from a well-established supply chain.[97] Hobday[98] explains that complex product production often requires the coordination of several producers (or suppliers) working together. This joint-action effectiveness is built over time through dense and continuous interactions between organisations (i.e. inter-organisational learning) (see chapter 2, subsection 2.4.2).[99]

Managerial challenges at this level are primarily the consequence of the requirement for combination of extraordinary skills and abilities along with, sometimes, a high 'pace' of technological change.[100] They are also the consequence of problems such as the non-recognition of common practices between complex systems (e.g. practices are very sector-specific, few recognised learning curves).[101]

The satellite developer (or prime constructor) should outsource with confidence. They should develop in-house ability to assess supplier deliverables (i.e. technical specifications, quality, cost and schedules). At the same time, the prime should develop their negotiation skills. The latter are necessary for resolving conflicts between different actors involved in the project. They are also useful for building partner-type relationships with suppliers. This is realised by involving them more and encouraging them to share goals, achievements and pressure.[102]

However, in the context of complex technology, density and continuity of interactions are insufficient. The technical architecture of the product matters in shaping the strategy of the organisation and whether parts of the product are insourced or outsourced. [103] Indeed, knowledge flow between an organisation and its suppliers is influenced by the product architecture and particularly how loose (or strong) the coupling between its components is. It is less complicated to outsource production when the coupling is loose, whereas production is often insourced when the coupling is strong. Consequently, satellite developers should consider the technical architecture when devising their interactions with suppliers and partners.

Satellite developer actions should be built on prior knowledge of the environment. This knowledge stems from an internal effort made by the organisation, fostered by a larger strategy adopted at higher level (e.g. sector, country level). Any strategy should be preceded by an accurate tracking of who is doing what, through regular industry surveys, promoting relationships with industry associations and exploiting data available from government agencies (on firms and contracts).[104]

Particular attention should be paid to strategies sustaining value-creating industries. There is a need to identify the ingredients of efficient innovation systems, such as education, skills development and long-term investment in R&D.[105]

3.6 Small satellite capability-building in developing countries

Small satellite capability-building in developing countries has rarely been addressed in the literature. The few works that have studied the issue offer a more general treatment, in that the emphasis was more on space technology than small satellite technology. They can be regarded as international comparative studies rather than country-specific studies.[106] Their levels of aggregation do not capture enough of the peculiarities of small satellite technology. They also do not thoroughly cover considerations of technology transfer to developing countries.

3.6.1 Mechanisms for small satellite technology transfer

The dynamics that have emerged over the last twenty-five years in building small satellites have lowered barriers to entry for newly industrialised and developing countries (e.g. South Korea, Malaysia, Turkey, Algeria, Nigeria, and Chile).[107] These countries have engaged in a process aimed at moving from passive status (i.e. user) to a more active status (i.e. operator and then manufacturer). Wood & Weigel[108] identify four models that have been used by these countries for implementing early satellite projects.

Turnkey projects are used where the customer is only in charge of operating the satellite after its launch, and managing its applications. This model is generally used to procure high capability (i.e. performance and advanced technology) satellites. Local university projects are the model for local organisations favouring training benefits over capabilities. In this model, much of the development effort is spearheaded by a local university (e.g. design, training, manufacturing and operation). Overseas education with local development is the third model. It refers to the situation where local organisations seek to use knowledge acquired abroad for developing satellites locally. This model is generally used when the local organisation wants to leverage foreign knowledge to facilitate and speed up local development. The fourth model is collaborative satellite development. It refers to projects where a combination of academic and hands-on technical training is provided to the customers' engineers and scientists. It often involves countries seeking to take their first steps in satellite technology on an affordable budget. The customer's engineers spend time and work together as a team with supplier engineers to build and launch the satellite. Then, the customer's engineers solely operate the satellite. The mentoring provided by the supplier's engineers enables the customer's engineers to commence working on complex systems and honing the diverse set of skills required for satellite development. In this model, the supplier leads the process of satellite design and manufacture.

The present research focuses on the use of the fourth model, as it is the mechanism used by Algeria for building small satellite capabilities.

3.6.2 Collaborative project characteristics

Wood & Weigel[109] studied collaborative satellite development projects in four developing countries. They argue that at least three archetypal models of satellite projects are used: the politically-pushed project; the structured project; and the risk-taking project. Wood & Weigel's study reveals that during the capability-building process, developing countries are likely to transition from the politically-pushed project to either the structured or risk-taking project. Decisions on models to initially adopt or transition to are strongly shaped by the national context and the leadership style of the host organisation.

Wood & Weigel [110] point out the particular challenges that are faced during collaborative project implementation. Collaborative project models are chosen according to the internal capabilities of the host organisation (e.g. absorptive capacity) and its ambition, balanced by the supplier's willingness to transfer technology (see chapter 2, subsection 2.6.3).

Three training types are generally provided during these projects: theoretical, practical and on-the-job.[111] The first refers to learning from courses or documentation. It is usually assessed through a formal mentoring system and formal accountability (e.g. academic evaluation, tests, dissertations and presentations). The results of theoretical training are relatively easy to convey to the host organisation for control purposes.

The second (practical training) refers to the application of skills learnt through practical work and on tasks that are not necessarily related to the manufactured satellite. This training is recommended when trainee skills are below those required for satellite manufacture. It is usually assessed through an informal mentoring system and "informal" accountability. It is relatively difficult to control by the host organisation.

The third (on-the-job training) refers to practical tasks performed by the trainee, under the supervision of a mentor, towards building the actual satellite. These activities are suitable when trainee skills match the skills required for satellite manufacture. Trainee contribution is assessed like any other team member's contribution. On-the-job activity is relatively difficult to control by the host organisation.

Each archetypal model used in collaborative projects has its strengths and weaknesses in terms of learning opportunities offered to the transferee. Table 3-3 summarises these opportunities at individual and organisational levels. The common difficulty across all cases remains the monitoring and assessment of training by the host organisation.[112] This difficulty increases if the training is conducted far away from customer countries.

Table 3-3: Learning opportunities according to the archetypal models of collaborative satellite projects

		Political pushed project	Structured project	Risk taking project
Phase of project experienced		Phase C and D*	Phase A/B to Phase D*	Phase A to Phase D*
Mentorship		Informal and flexible	Formal (defined and documented)	Mix of formal and informal
Individual training	Theoretical training	N/P	Strong	N/P
	practical training	Strong	Strong	Strong
	on the job training	Medium	N/P	Strong
Advances in areas of organisational accomplishment	autonomy	Low	Low	High
	complexity	Low	High	Medium
	New topics coverage	High (because the entire satellite is unfamiliar)	High	High

N/P: not provided
*according to NASA's generic satellite lifecycle:
Phase A: Conceptual design (needs identification, technical requirements , mission overall concept, feasibility)
Phase B: Preliminary design phase (initial detailed design)
Phase C: Detailed design and fabrication (or subsystem manufacture)
Phase D: System Assembly, Integration, Test and Launch

Source: adapted from Wood, D.R., 2012. Building technological capability within satellite programs in developing countries. PhD Thesis, MIT, pp.160-191. And, Wood, D., Weigel, A., 2014. Architectures of small satellite programs in developing countries. Acta Astronautica 97, 109–121.

3.7 Comparative experiences

The mechanism of collaborative projects is popular and regarded as the most common for satellite technology transfer to developing countries. However, due to the immaturity of experiences and projects carried out hitherto, it is difficult to either support or reject the idea that this mechanism has been successfully used for building satellite technology capability in developing countries. South Korea remains the only state that has gained in maturity and provides enough lessons to be analysed. Additionally, some lessons can be learnt from the Indian satellite development path, which unfolded well before South Korea's. The Indian experience started out with traditional satellites under very constricted conditions: an unfavourable national economic and technological situation, lack of confidence among the population, and a global environment fairly closed to international exchange in satellite technology.

3.7.1 South Korean satellite development experience

In 1989, Korea commenced space technology development activities by creating the Korean Aerospace Research Institute (KARI), effectively acting as the national space agency.[113] At the same time, the Koreans created the Satellite Technology Research Centre (SatReC), a university-based research centre for satellite technology and applications.[114]

Satellite development in Korea was initiated through collaborative small satellite projects. SatReC partnered with the UK's University of Surrey to build the first Korean satellite KITSAT-1 that was launched in 1992. The main objective of this programme was to acquire technology through training and education.[115] A group of recent Koreans graduates in engineering was sent to the UK to work with the University of Surrey team on the satellite. They had just finished their undergraduate programmes in a premier technical university in South Korea and lacked any specific training in satellite engineering.

At the same time, SatReC formed a second, complementary team that remained in South Korea. Once KITSAT-1 development was completed, Korea purchased the same components as had gone into KITSAT-1 from the UK. Back in Korea, both teams were put together to assemble KITSAT-2 independently, an identical satellite to the first satellite.[116] The main objective of KITSAT-2, launched in 1993, was to verify that the knowledge conveyed in the KITSAT-1 programme had been absorbed by the Koreans.[117]

In 1994, building on the experience and knowledge acquired in the previous programmes, the same SatReC team attempted to design and build locally another small satellite: KITSAT-3. The main objective of this satellite, launched in 1999, was to mark Korea's indigenisation of satellite manufacturing.[118] The same year, SatRec Initiative (SI) was founded; a university spin-out company formed by the engineers involved in KITSAT-1, -2 and -3.[119]

Since then, SI has improved its capabilities, moved to higher levels of complexity and diversified its products. It has successfully developed and exported products covering the whole spectrum of remote sensing missions (e.g. satellites, platforms, electro-optical instruments, communication systems, ground systems and application software) as well as products for defence systems and nuclear safety.

In parallel to the maturation of this university-level embryonic experience built through collaborative projects, the leadership of Korea's satellite development shifted to KARI (Korea space agency).[120] In 1996, a national space development plan was established covering the period 1996-2015, envisaging the development of capabilities across the entire spectrum of space technology (i.e. satellites, launch vehicles, applications and space science).[121]

Mid-term objectives were specified. For instance, the plan aimed to independently develop a low Earth orbit (LEO) multi-purpose satellite by 2010. It aimed to acquire capability to launch micro-satellites by 2007, and to establish the technical basis for competing in the global space market.

The long-term objectives were to develop independent core technological capabilities, to join the ranks of the top 10 countries in the global space industry, to improve quality of life, and to inspire Korean pride and achievement.[122]

In order to achieve these objectives, a twin-track approach was adopted. Korea relied on foreign technology to develop and place space systems into orbit, as well as foster indigenous technology through international cooperation.[123] Impressive development in space capabilities, particularly satellite technology, has been achieved under the space development plan.[124]

Increasing achievements, a steady move towards greater technical autonomy and complexity, and the growing national importance of space have been accompanied by elevating the government body responsible for space policy. In 2005, the National Space Committee was established as the supreme government body for drafting space policy. It was placed under the control of the President, chaired by the Minister of Science and Technology, and composed of many members, including ministers.[125]

In South Korea, space technology development has mainly been a government business throughout the whole value chain, either via government research institutes or through international cooperation. Government planned space activities, implemented the policy, carried out research and development, and commercialised space systems and products. This government-centred industrial strategy led to major impediments to space industry growth. [126] It has limited private sector involvement and limited support from the government to private companies wishing to enter this market. This is reflected in the dearth of space systems manufacturing companies.[127] Monopolisation into a few principal government research institutes has led to weak research-industry communication and limited technology transfer from research institutes to space companies.[128]

To address these deficiencies, Lee & Chung[129] argue that the principal government research institutes should expand their missions from a “research-only laboratory to a manager and supporter of space development and industry”.[130] This will be enabled by promoting a wider space industry, facilitating communication between companies, encouraging technology transfer to the private sector, and supporting private companies (e.g. sharing expensive equipment, facilities and information with them). There is also a need to increase the number of satellite development projects, along with their monetary value, so as to entice more Korean companies to get involved.[131]

3.7.2 India’s satellite development experience

India offers an outstanding example of changing perceptions by way of a challenging space programme. It demonstrates that even deep-rooted national and international negative perceptions towards a nation’s capabilities can change swiftly as the national community gains confidence. India’s space programme was brilliantly initiated and was shaped by a clear-cut vision: “be second to none in the development and application of space technology to the solution of real problems of man and society”.[132]

Central to this vision is the use of advanced technology like that for space for accelerating the national development process. The Indian strategy also emphasises self-reliance and "application through an understanding of basic technology".[133] The strategic vision also emphasises the importance of international cooperation in capability-building and for bridging gaps in development.[134]

This strategic vision has evolved and has successively been adapted and enriched. It emphasises organisational culture and links with users, development of space-related industry, use of space as a tool for sustainable development, a holistic and diversified approach to growth, a planetary vision and, finally, space exploration.[135] To implement this strategy, a planning approach has been adopted defining long-, medium- and short-term goals.

As a result, the Indian space programme began in a modest way in 1962, however, five decades later, all segments of the space programme, namely satellite communications, meteorology, Earth observation system, and launch vehicles, are operational, commercialised and with industrial spin-offs. Moreover, India inaugurated a moon mission, is working on manned flight missions, and is now planning to venture into interplanetary space.[136]

With regard to satellite technology in India, Baskaran[137] analyses technological learning that occurred between the early 1970s and the late 1990s. He examines the judicious combination of active international cooperation along with strong local efforts throughout the various phases of satellite capability-building. He divides the capability building process into two phases: the formative phase (1971-1985) and the accumulative phase (since 1986). Noteworthy is that "in the early 1970s, India's capability in all aspects of satellite technology was nearly zero".[138]

In the formative phase, India started importing subsystems and assembling them into whole systems. Then, it imported most of the components (and developed some locally) and assembled them into subsystems. Finally, it manufactured most of the subsystems using mostly local components. The foreign contribution in the formative phase was critical. India cleverly diversified its partners, which seems to have been a strategic choice to increase technology transfer opportunities and overcome possible setbacks.[139] It relied on the Soviet Union for remote sensing satellites, and the USA, France and other European countries in communication satellites. Baskaran[140] points out that, to all appearances, during this phase India could access almost all technologies without major obstacles. He stresses also the prevailing role of local effort during this phase.

The accumulative phase is marked by the threshold that India attained in terms of capabilities for building satellites locally (e.g. design, fabrication, testing, integration, control, simulation, appropriate facilities, management and commercialisation). During this period, India's dependence on foreign technology decreased in general. However, the steady move towards greater technical complexity made the dependency stronger in terms of complex components, especially under a stringent new export restriction regime. Consequently, India adopted a new strategy towards establishing indigenous research and development for the most critical components.

In sum, India gradually built up sustainable capabilities and reduced dependence on foreign technology. It fostered linkages between ISRO's[141] internal entities, local universities, R&D organisations and industry, including the public and private sectors. In parallel, and since the mid-1970s, it gradually enlarged the size of its space market by increasing the number of projects, diversifying themes, and encouraging the entry of new local suppliers across the value chain segments.

The strategy was to foster supplier networks by means of a technology transfer programme from ISRO's entities towards public and private companies. The strategy was also to support suppliers by training and sharing information and facilities, prototype development and applied R&D. Basic R&D was kept under ISRO or R&D entities. Development and engineering aspects were transferred to industrial firms (public and private) by involving them in R&D related to production problems. Since the late 1990s, new strategies towards the international market have been devised and international collaboration remains key to their implementation.

The literature reviewed in chapters 2 and 3 allowed the selection of a knowledge-oriented approach for the evaluation of small satellite technology transfer and capability-building in Algeria. Chapter 2 placed technological learning at the heart of the present thesis. The learning perspective has been substantiated by theoretical perspectives stemming from traditional bodies of knowledge: technology transfer (i.e. involving exogenous factors) and technological capability-building (i.e. involving endogenous factors). These factors are categorised at individual and team level (i.e. micro level), organisational level (i.e. meso level), and sectoral, national and international level (i.e. macro level). Macro considerations were further discussed using the Innovation System analytical approach.

Chapter 3 has linked the considerations reviewed in chapter 2 underpinning technological learning, technology transfer, technological capability-building, and innovation systems, with the peculiarities of small satellite development in the context of developing countries. Managerial challenges related to small satellite technology development has been explored from the perspectives that small satellites are complex systems (CoPS) and systems developed under the FBC (Faster-Better-Cheaper) philosophy. The literature findings have guided the formulation of the evaluation framework detailed in the following chapter.

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[81] Salazar, VK., 2012. Emerging Trends in the Satellite Industry. MSC dissertation, MIT Sloan School of management, p.24.

[82] Maturity refers to technologies that are well beyond laboratory stage of development. Concepts of Technology Readiness Level (TRL) and Manufacturing Readiness Level (MRL) can be used for characterising levels of maturity.

[83] Sandau (2010), op. cit.

[84] Hobday & Rush (1999), op.cit.

[85] Inspired by Sharif's four technology components: Technoware, Humanware, Infoware, and Orgaware. Sharif (1988), op. cit.

[86] Watzin (1999), op. cit.

[87] Ibid.

[88] Ibid.

[89] Ibid.

[90] Ibid.

[91] Hobday & Rush (1999), op.cit.

[92] Unlike the mechanistic management system that is appropriate to stable conditions, "the organic form is appropriate to changing conditions, which give rise constantly to fresh problems and unforeseen requirements for action which cannot be broken down or distributed automatically arising from the functional roles defined within a hierarchic structure". Burns, T.B., Stalker, G.M., 1961. The Management of Innovation. London: Tavistock, pp.103-108.

[93] Hobday & Rush (1999), op.cit.

[94] Ibid.

[95] Wertz & Larson (1996), op. cit.

[96] Lundvall (2005), op. cit.

[97] OECD (2014), op. cit., p.20.

[98]Hobday (1998), op. cit.

[99] Hargadon, A., 2013. Brokerage and Innovation. In: Dodgson, M., Gann, D.M., Phillips, N., (Eds.). The Oxford Handbook of Innovation Management. Oxford University Press, Oxford, pp. 163-180.

[100] Hobday & Rush (1999), op.cit.

[101] Hobday & Rush (1999), op.cit.

[102] Watzin (1999), op. cit.

[103] Baldwin (2010), op. cit.

[104] OECD (2014), op. cit., pp.31-33.

[105] OECD, WTO, WB, 2014. Global value chains: challenges, opportunities and implications for policy. OECD, World Trade Organisation, Wold Bank. Report prepared for submission to the G20 Trade Ministers Meeting, Sydney, Australia, 19 July, www.oecd.org/tad/gvc_report_g20_july_2014.pdf (Accessed on 30/10/2015)

[106] Examples:

Jason, S., Curiel, A., Liddle, D., Chizea, F., Leloglu, U.M., Helvaci, M., Bekhti, M., Benachir, D., Boland, Lee., Gomes, L., Sweeting, M., 2010. Capacity building in emerging space nations: Experiences, challenges and benefits. Advances in Space Research 46, 571–581.

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Leloglu, U.M., Kocaoglan, E., 2008. Establishing space industry in developing countries: Opportunities and difficulties. Advances in Space Research 42, 1879–1886.

Esterhazy, D. 2009. The role of the space industry in building capacity in emerging space nations. Advances in Space Research 44, 1055–1057.

Wood, D., Weigel, A., 2012. Charting the evolution of satellite programs in developing countries – The space Technology Ladder. Space Policy 28, 15-24.

Kramer, H.J., Cracknell, A.P., 2008. An overview of small satellites in remote sensing. International Journal of Remote Sensing 29(15), 4285–4337.

[107] Wood, D., Weigel, A., 2014. Architectures of small satellite programs in developing countries. Acta Astronautica 97, 109–121.

[108] Ibid.

[109] Ibid.

[110] Ibid.

[111] Ibid.

[112] Ibid.

[113] KARI, 2015. Korean Aerospace Research Institute- KARI, http://eng.kari.re.kr/sub04_04 (Accessed on 16/11/2015)

[114] Satellite Technology Research Centre- SatReC, located in Korea Advanced Institute of Science and Technology -KAIST, http://satrec.kaist.ac.kr/english/SaTReC.html (Accessed on 16/11/2015)

[115] Hwang, C.Y., 2006. Space activities in Korea—History, current programs and future plans. Space Policy 22, 194–199.

Lee, J.J., Chung, S., 2011. Space policy for late comer countries: A case study of South Korea. Space Policy 27, 227-233.

[116] Wood (2012), op. cit., pp.62-64.

[117] SatReC, 2015. Satellite Technology Research Centre- SatReC, http://satrec.kaist.ac.kr/english/SaTReC.html (Accessed on 16/11/2015)

[118] Hwang (2006), op. cit.

SatReC (2015), op. cit.

[119] SatRec Initiative-SI, https://www.satreci.com/eng/ (Accessed on 16/11/2015)

[120] Lee & Chung (2011), op. cit.

[121] Hwang (2006), op. cit.

[122] Lee & Chung (2011), op. cit.

[123] Park, W.H., 2010. Recent space developments in South Korea. Space Policy 26, 117-118.

[124] Example of achievements: Science and Technology Satellite series (STSAT-1, 2), Korea Multi-Purpose Satellite projects (KOMPSAT-1, 2), KOREASAT series (KOREASAT-1, 2, 3, 4, 5). Communication, Ocean and Meteorological Satellite (COMS), Korean Science Rocket series (KSR-1, 2, 3), Korean Satellite Launch Vehicle-I (KSLV-I) and KSLV-2, Korea Astronaut Programme, participation in a Global Navigation Satellite System (GNSS) Project and the International Space Station (ISS). Lee & Chung (2011), op. cit.

[125] Hwang (2006), op. cit.

[126] Lee & Chung (2011), op. cit.

[127] Ibid.

[128] Ibid.

[129] Lee & Chung (2011), op. cit.

[130] Ibid., p.227.

[131] Hwang (2006), op. cit.

[132] Dr.Vikram Sarabhai, the founder architect of the space programme, gave shape to this vision in the 1960s through several of his writings, speeches and programme initiatives, unfolding the multifarious dimensions enveloping this vision. http://www.isro.gov.in/about-isro/dr-vikram-ambalal-sarabhai-1963-1971 (accessed on 18 May 2017).

[133] Murthia, K.R.S., Madhusudanb, H.N., 2008. Strategic considerations in Indian space programme—Towards maximising socio-economic benefits. Acta Astronautica 63, p.504.

[134] Ibid., pp.503–508.

[135] Ibid.

[136] Indian Mars orbiter mission, http://www.isro.gov.in/pslv-c25-mars-orbiter-mission (accessed on 14 January 2015)

[137] Baskaran, A., 2001. Competence building in complex systems in the developing countries: the case of satellite building in India. Technovation 21, 109-121.

[138] Ibid., p.117.

[139] Waswa, P.M.B, Juma, C., 2012. Establishing a space sector for sustainable development in Kenya. International Journal of Technology and Globalisation 6(1-2), 152-169.

[140] Baskaran (2001), op. cit.

[141] Indian Space Research Organisation-ISRO is the Indian Space Agency.

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Chapter 4: Small satellite capability-building: an evaluation framework

Drawing on the literature surveyed in previous chapters, two fundamental ideas arise for the evaluation of technological capability-building and technology transfer in the context of developing countries. The first is that technological capability-building is affected by a multitude of factors at individual and team level (i.e. micro level), as well as at organisational level (i.e. meso level), and also within the sectoral, national and international environment (i.e. macro level). Accordingly, any attempt at a comprehensive evaluation should be performed at all levels (micro, meso, and macro).

The second idea stems from the analysis of technological change occurring in developing countries (see chapter 2, subsection 2.5.3), which reveals that technological capability in these countries is built according to the sequence: engineering, development, and research.[1] Accordingly, the starting point for the evaluation in the context of the present thesis is the small satellite itself: its engineering, development work surrounding it, and related research activities. This sequence corresponds to a gradual evaluation from micro level, where individuals and teams engineer the satellite, up to meso and, ultimately, macro level, where the development and research environment has salience.

The purpose of this chapter, then, is to present the evaluation framework used in the present study. Firstly, the Innovation System analytical approach (described in chapter 2, subsection 2.7.3) is used to examine the wider context (macro environment) through the analysis of Algeria's satellite innovation system (actors, networks and institutions). Secondly, the planning of the small satellite capability-building programme is evaluated by using the 'strategic planning' analytical tools (e.g. PESTEL[2] and SWOT[3]).

Thirdly, the implementation of Algeria's small satellite capability-building programme is evaluated by using the framework devised in this study and described below (section 4.1). The framework is formed of three categories of evaluation metrics: (i) metrics related to technological learning; (ii) metrics related to locally built technological capabilities; and (iii) metrics related to transferred technology. These metrics are applied at micro, meso and macro levels. As the present evaluation lies essentially within the knowledge-based tradition,[4] the approach examines primarily knowledge flow, or learning, where complex technology is transferred. Performance related to technological learning is therefore at the heart of this evaluation (section 4.2). To ensure a systemic evaluation of technological learning, two systemic models, encompassing various metrics, are devised and presented in sections 4.3 and 4.4.

4.1 Metric categories

The multitude of factors which affect technological capability-building and technology transfer to developing countries are spread over different analytical levels. These factors, from which the evaluation metrics derive, form the analytical framework used for examining the implementation of the satellite capability-building programme. They are gathered according to three major categories illustrated in Table 4-1 : (i) metrics related to Technological Learning (M.T.L) for measuring the knowledge acquired during the transfer and locally diffused; (ii) metrics related to locally built Technological Capabilities (M.T.C) for measuring the level of organisational capabilities and their complexities; and (iii) metrics related to Transferred Technology (M.T.T) for measuring the factors that are at the nexus between transferor and transferee.

Needless to mention, these categories overlap in certain respects. This is a deliberate choice so as to enhance the evaluation’s credibility through theoretical triangulation.[5] The latter refers to the use of diverse theoretical perspectives stemming from multiple bodies of knowledge: technological learning, technological capability-building, and technology transfer.

Evaluation of satellite technological learning is performed through six sub-categories of metrics described in Table 4-1. In the same way, evaluation of the locally built satellite technological capabilities and the transferred satellite technology is performed according to their particular sub-categories of metrics, respectively two and five sub-categories, as sketched out in Table 4-1.

Table 4-1: Categories of evaluation metrics

Categories		Subcategories
Metrics related to Technological Learning (M.T.L)	1	The velocity and viscosity of the knowledge handled and whether the velocity/viscosity balance is appropriate
	2	The level of component and architectural knowledge acquired and whether the mix is appropriate.
	3	The level of individual, group, organisational and inter-organisational learning and whether the interplay between them is effective.
	4	The level of prior knowledge required to build satellite capabilities (as part of the absorptive capacity)
	5	The level of learning by doing, learning by searching and learning by interacting, and whether these learning types are appropriately combined.
	6	The level of explicit and implicit knowledge acquired and whether the mix is appropriate.
Metrics related to locally built Technological Capabilities (M.T.C)	7	The level of organisational (or physical) capabilities that have been built, human capital, information, and their integration through appropriate management.
	8	The degree of complexity of capabilities and the interplay with engineering, development and research efforts.
Metrics related to Transferred Technology (M.T.T)	9	The nature and content of technology components that are transferred: Technoware, Humanware, Infoware, and Orgaware.
	10	The maturity level of transferred technologies or the developmental stages which they are in in their countries of origin
	11	The strength of relationship between the transferor and transferee
	12	The appropriateness of the mechanism used for technology transfer (collaborative projects).
	13	The appropriateness of the transferee's management practices (fostering learning culture within a technology transfer context).

Source: Author (synthesised from the literature review in chapters 2 and 3).

The above-identified sub-categories of metrics apply at different levels of analysis (micro, meso and macro) as illustrated at the end of this chapter (section 4.5, Tables 4.3, 4.4 and 4.5). For instance, when it comes to measuring the level of prior knowledge required to build satellite capabilities, at a micro level this refers to prior individual technical skills and team managerial skills. At a meso level, this refers to the transferee's organisational knowledge that is already available to build a satellite. At a macro level, this refers to inter-organisational, or broad sectoral, knowledge (national and international) that is part of the satellite technological innovation system. Similar reasoning is applied to the rest of the metrics.

4.2 Centrality of technological learning metrics in the evaluation

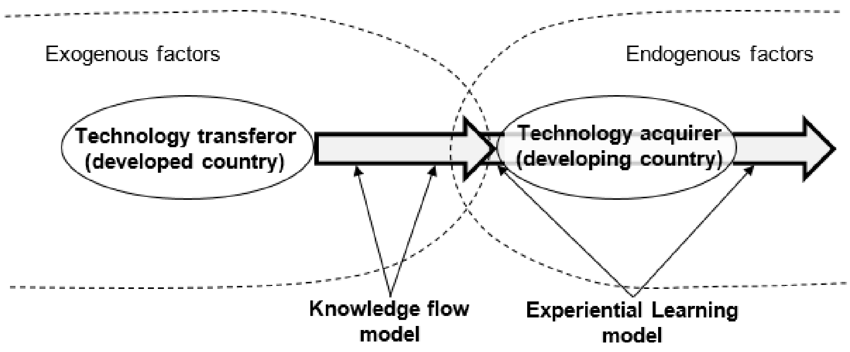
One way of evaluating technology transfer and technological capability-building is to adopt what Cohen[6] calls the 'engineering perspective'. It posits that knowledge cannot be considered as transferred until it has been used or applied. This perspective fosters the use of evaluations having two purposes: judgment or improvement. Such evaluations prevail in technology transfer from developed to developing countries and have been re-adopted, inappropriately, by developing countries for certain complex and knowledge-intensive projects.

These traditional evaluation approaches have inherent limitations that preclude a deeper understanding of the phenomenon in question. Indeed, learning (or knowledge transfer) is often a slow and laborious process.[7] It rarely produces swift, tangible outputs, and does not necessarily lend itself to traditional ways of evaluation based on the 'instrumental' use of outcomes and results. For this reason, a move towards knowledge-generating evaluations might be highly valued, as suggested by Patton.[8]

Accordingly, the present evaluation lies essentially within the knowledge-based tradition.[9] It looks at knowledge flow, or learning, where satellite technology is transferred from developed to developing countries.

Technological learning is the central element of this evaluation. Table 4-1 sketches out six subcategories of interwoven learning metrics. Any separate or isolated measurement of these metrics during the evaluation is likely to weaken the systemic nature of the evaluation. Hence, two systemic models, encompassing the six subcategories of technological learning, are devised in the present thesis. These models are devised for evaluating the flow of knowledge from its first transfer at the transferor-transferee interface to its local diffusion (Figure 4-1).

Figure 4-1: Positioning of the proposed evaluation models



Source: Author.

The first model is called the 'knowledge flow model'. It is devised to evaluate knowledge transfer at the departure point from transferor to transferee (Figure 4-1). It evaluates the transferred knowledge during collaborative satellite projects in which transferor and transferee teams were mixed. This model is built by using the Davenport & Prusak[10] concepts of knowledge 'viscosity' and 'velocity' (subcategory 1 in Table 4-1), along with the Henderson & Clark[11] concepts of 'architectural' and 'component' knowledge (subcategory 2 in Table 4-1).

The second model is called the 'experiential learning model'. It is devised to evaluate post-project knowledge transfer. This model applies after the technology has been transferred from abroad via collaborative projects. It evaluates the locally transferred (or diffused) knowledge meant to build local capabilities (Figure 4-1). The model is built by combining the three types of technological learning: learning by doing, learning by searching, and learning by interacting (subcategory 5 in Table 4-1), occurring at various learning levels (individual, group, organisation and inter-organisation) (subcategory 3 in Table 4-1).

Prior knowledge required for building a satellite (subcategory 4 in Table 4-1) and the form (tacit and explicit) of the acquired knowledge (subcategory 6 in Table 4-1) are measured across these two models.

4.3 Knowledge flow model

4.3.1 Knowledge velocity vs viscosity and component vs architectural knowledge

Knowledge flow in this model is addressed by combining the two knowledge typologies presented in chapter 2 (section 2.4). The first draws on the concepts of knowledge 'velocity' and 'viscosity' introduced by Davenport & Prusak[12] (chapter 2, subsection 2.4.3). They argue that successful knowledge transfer is usually achieved through a delicate balance between velocity and viscosity. They explain that the relationship between velocity and viscosity is indirectly proportional, as often factors that lead to high velocity are those leading to thin viscosity and vice-versa. Schwartz et al.[13] support the argument and contend that in general the transfer mode adopted is a compromise between high velocity and acceptable viscosity.

The delicate velocity-viscosity balance for effective transfer is closely tied to the nature of the knowledge that circulates and the actors involved in the transfer. In the technological and industrial context, knowledge is very often thought of as a resource that includes two complementary components: tacit and explicit knowledge (chapter 2, subsection 2.4.1). In addition, acquiring new knowledge hinges on the absorptive capacity of the actors involved (chapter 2, subsection 2.4.6).

The second knowledge typology refers to Henderson & Clark's[14] concepts of 'component' and 'architectural' knowledge (chapter 2, subsection 2.4.4). For acquiring technology, the literature on strategy and innovation suggests that organisations with limited resources, such as those in developing countries, need to make a trade-off between architectural and component knowledge. Other literature (e.g. on transaction cost economics and system engineering) acknowledges the inversely proportional relationship between the number of components (or component knowledge) and the architecture (or integrative knowledge) when it comes to resource-limited firms.

4.3.2 Implications of complex technological systems

As detailed in chapter 3 (section 3.4), three important aspects stand out from the complexity characteristics of a product. The first is the number of components we need to know about. It relates to the diversity (or breadth) of component knowledge that the system integrator requires. In this respect, we should not overlook the depth of knowledge that relates to each component; that is, the knowledge required to generate these components.[15] Indeed, the components of complex systems are not 'simple' components; they are themselves architectures (e.g. modules, subsystems) connecting other components or, rather, subcomponents. Therefore, components, as knowledge-gathering entities, can be seen as a microcosm of the larger system as they share common features with it.

The second aspect of complexity refers to the level of proficiency (or depth) needed to manage the interdependencies between components. This is the concern of architectural knowledge.[16]

The third aspect relates to knowledge novelty required for building a complex system. It concerns both component and architectural knowledge. Indeed, acquiring new knowledge hinges largely on the 'absorptive capacity' of learners. That can be broken down into the abilities enabled by prior knowledge (knowledge accumulation), and the intensity of learning effort. Kim[17] argues that the intensity of organisational effort, through actions leading to both continuous and discontinuous learning, has a more prominent role than prior knowledge, particularly for long-term learning.

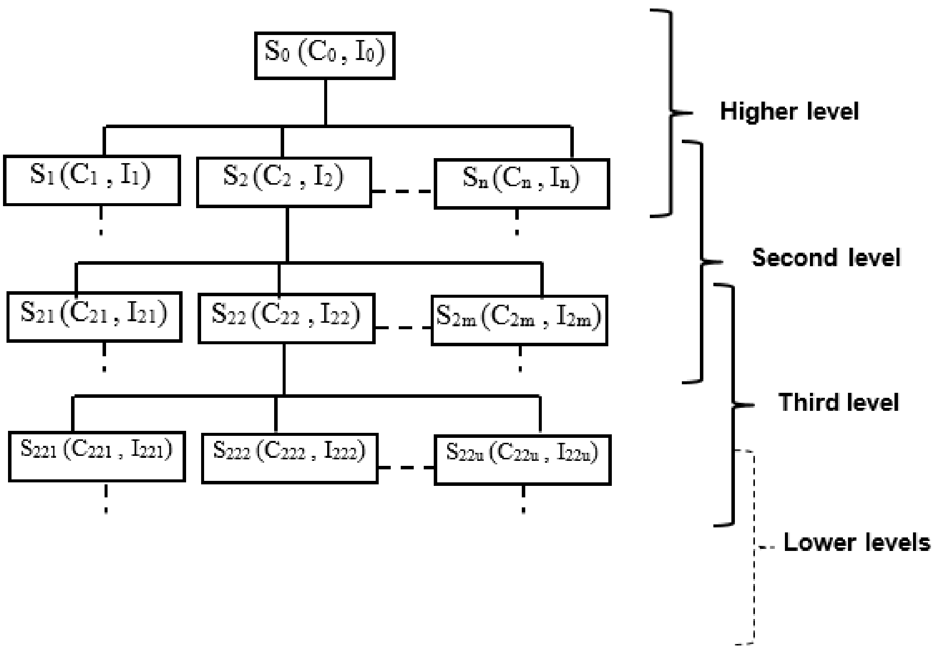
4.3.3 Formulating the model

Building on Henderson & Clark's[18] knowledge typology and complex technology characteristics, successful transfer of a technological system is akin to effective learning in respect of the system architecture and components. The technology acquirer should therefore acquire the knowledge that relates to the core design concepts of each component, as well as to the architectural (or integrative) knowledge required to put together these components to form a system.

However, in accordance with the system engineering view, a technological system is also perceived as a decomposition-integration process. The technological system is an architecture gathering together several components, and each component is further decomposed into several subcomponents. The decomposition continues down to the lowest level of decomposition (e.g. hardware, software). On the other hand, the lowest level entities are integrated together, validated and tested to form higher level entities, and the process flows up to the system level. The selection of the decomposition approach is often driven by the need to, for instance, integrate easily, to upgrade easily, to develop easily, as well as to simplify management accountability.[19]

To ease understanding of the proposed model, the example of a product breakdown structure (PBS) in Figure 4-2 illustrates the decomposition-integration process associated with the technological system transferred. In general, system complexity is reflected through multiple levels of decomposition and the number of components at each level.

Figure 4-2: Component and integrative knowledge through the Product Breakdown Structure



Source: Author.

Let S denote the components of the technological system. At the highest level, S_0 denotes the final integrated product (or the technological system). S_1, S_2, …, S_n denote the subcomponents of S_0. At the second level, S_{i1}, S_{i2}, …, S_{im} denote the subcomponents of S_i. At the third level, S_{ij1}, S_{ij2}, …, S_{iju} denote the subcomponents of S_{ij}, and so on until the lowest level of decomposition is reached.[1] For instance, the INCOSE systems engineering handbook defines seven decomposition levels (system, segment, element, subsystem, assembly, subassembly and part).[20]

Based on the Henderson & Clark's[21] knowledge typology, it can be posited that each component of the technological system relates to two types of knowledge: component knowledge C and integrative (or architectural) knowledge I. The pair (C_0 , I_0) refers to component and integrative knowledge related to component S_0. (C_1 , I_1), (C_2 , I_2), …, (C_n , I_n) refer, respectively, to component and integrative knowledge related to components S_1, S_2, …, S_n.

At the second level, (C_{i1} , I_{i1}), (C_{i2} , I_{i2}), …, (C_{im} , I_{im}) refer, respectively, to component and integrative knowledge related to components S_{i1}, S_{i2}, …, S_{im}.

At the third level, (C_{ij1} , I_{ij1}), (C_{ij2} , I_{ij2}), …, (C_{iju} , I_{iju}) refer, respectively, to component and integrative knowledge related to components S_{ij1}, S_{ij2}, …, S_{iju}.

There is an assumption that component knowledge C of any component is the entire knowledge that is needed in order to build this component. This 'whole' knowledge is the combination of the knowledge of its composing elements (components) along with the knowledge required to integrate these elements. In other words, the knowledge that is needed to be acquired (or transferred) in order to build the component is simply its component knowledge. Let KT denote the knowledge acquired (or transferred), then for each component of the system:

[1] n, m, u refer to the numbers of components at each level of decomposition.

$KT_0 = C_0 = C_1 + C_2 + ... + C_n + I_0$ (1), where $C_1, C_2, ..., C_n$ refer to the components' knowledge and I_0 is the knowledge required to integrate these components.

…

$KT_2 = C_2 = C_{21} + C_{22} + ... + C_{2m} + I_2$ (2)

…

$KT_{22} = C_{22} = C_{221} + C_{222} + ... + C_{22u} + I_{22}$ (3)

….

The proposed model serves to illustrate the interplay between component and integrative knowledge in technology transfer. The flow of knowledge from transferor to transferee can be viewed differently by borrowing Davenport & Prusak's[22] concepts of knowledge 'viscosity' and 'velocity', explained earlier. For the purposes of the model, viscosity refers to the flow, in terms of depth, of knowledge transferred, and it specifically provides indication as to the depth of integrative knowledge required to put components together. Let KVis denote the knowledge that flows as a result of viscosity, then:

$KVis_0 = I_0$ (4)

…

$KVis_2 = I_2$ (5)

…

$KVis_{22} = I_{22}$ (6)

…

On the other hand, velocity refers to the speed with which knowledge moves during technology transfer project. Velocity provides an indication as to the number of topics (components) covered over the course of the project; that is, it provides an indication of the breadth of component knowledge transferred. This knowledge is reflected through the number and/or diversity of component knowledge transferred, and implicitly, the depth of knowledge associated with each component. Let KVel denote knowledge flow as a result of velocity, then:

$KVel_0 = C_1 + C_2 + \ldots.. + C_n$ (7)

…

$KVel_2 = C_{21} + C_{22} + \ldots.. + C_{2m}$ (8)

…

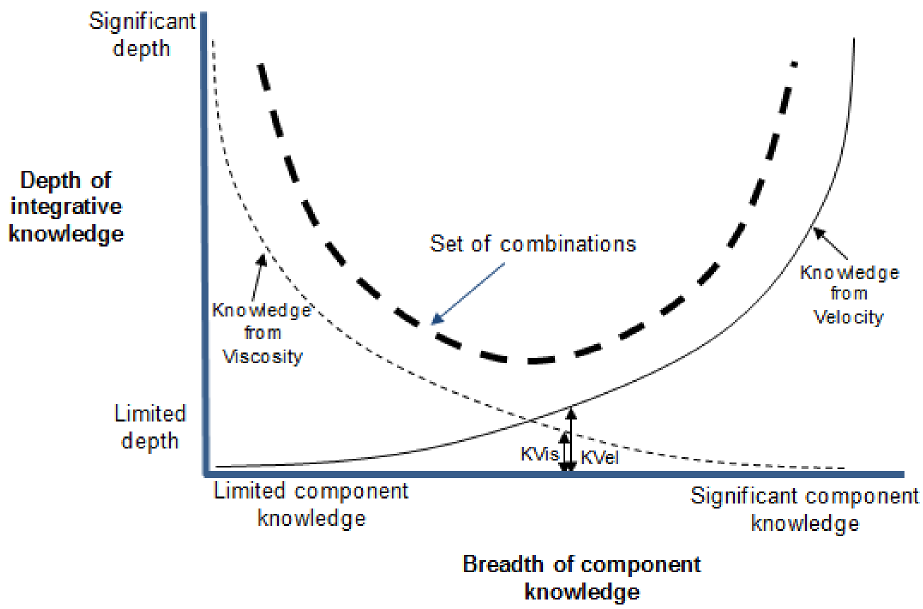
$KVel_{22} = C_{221} + C_{222} + \ldots.. + C_{22u}$ (9)

….

The knowledge transferred is a combination of two inversely proportional factors: breadth and depth (or knowledge from velocity and knowledge from viscosity). Figure 4-3 shows this delicate balance. The author would argue that the knowledge acquired for any component varies along the curve labelled "set of combinations" featured in Figure 4-3. Consequently, the knowledge transferred (KT) for each component of the system is given by:

KT = KVis + KVel (10)

Figure 4-3: Velocity vs Viscosity - Breadth vs Depth



Source: Author.

It is noteworthy that the velocity-viscosity balance is sought across all of the components of the technological system and at all levels of decomposition-integration, as illustrated in Figure 4-4. The knowledge transferred through each component can be represented by an equation combining two variables KVis (viscosity) and KVel (velocity):

$KT_0 = KVis_0 + KVel_0$ (11)

…

$KT_2 = KVis_2 + KVel_2$ (12)

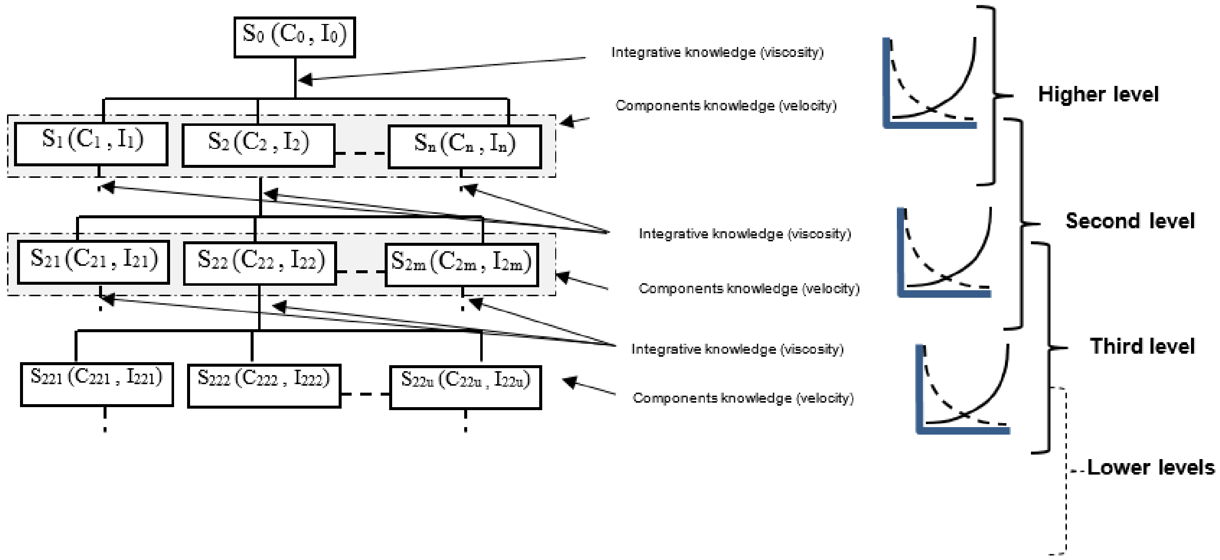
…

$KT_{22} = KVis_{22} + KVel_{22}$ (13)

…

The accumulation of balancing ‘games’, along with the reciprocal effect between components, reflects the difficulty of acquiring knowledge effectively. This is even truer in the context of technology transfer, where ‘balance’ choices are insufficiently well informed because of initial constraints on the knowledge acquirer (i.e. developing countries), such as limitations of prior knowledge which can enlighten choices.

Figure 4-4: Velocity vs Viscosity throughout the PBS



Source: Author.

Interplay between component and integrative knowledge

To explain the interplay between component and integrative knowledge, the technology acquirer's objective is assumed to be maximisation of the knowledge transferred. Thus, it is clear from (11) that an increase in knowledge transfer (KT_0) (related to the technological system) requires an increase in either the depth of knowledge ($KVis_0$) or breadth of knowledge ($KVel_0$), as the two factors are inversely proportional.

The **first scenario** is to increase the depth of knowledge, i.e. deepen integrative knowledge. This knowledge ($KVis_0$) can increase up to a point, but cannot go beyond a certain threshold, because it is related to the components. Indeed, it offers a margin for progress, but remains limited because it cannot go beyond a certain level of integration unless more is known about the components. Paradoxically, in order to know more about the components, there is a need to explore the second scenario.

The **second scenario** is to increase the breadth of knowledge ($KVel_0$), i.e. gain more knowledge about components. This knowledge is represented by $KVel_0$. From (7), to increase $KVel_0$, there is a need to increase C_1, C_2, …, or C_n. Firstly, the example of increasing knowledge about one of the components (C_2) is examined.

From (2), to increase knowledge about the component C_2, there is a need to increase knowledge about its subcomponents C_{21}, C_{22}, …, C_{2m}, which is equivalent to $KVel_2$ (see (8)) or its integrative knowledge I_2, which is equivalent to $KVis_2$ (see (5)). $KVis_2$ remains limited and cannot go beyond a certain threshold because it is related to the subcomponents. $KVel_2$ and $KVis_2$ are inversely proportional, and so as $KVel_2$ increases, $KVis_2$ decreases, and vice-versa. Similarly, the example of increasing knowledge about one of C_2's subcomponents (C_{22}) is examined.

From (3), to increase knowledge about the subcomponent C_{22}, there is a need to increase knowledge about its sub-subcomponents C_{221}, C_{222}, …, C_{22m}, which is equivalent to $KVel_{22}$ (see (9)) or its integrative knowledge I_{22}, which is equivalent to $KVis_{22}$ (see (6)). Likewise, $KVis_{22}$ remains limited and cannot rise above a certain threshold, because it is related to the sub-subcomponents. $KVel_{22}$ and $KVis_{22}$ are inversely proportional. In order to increase knowledge, the same rationale can be applied down to the lowest level of decomposition.

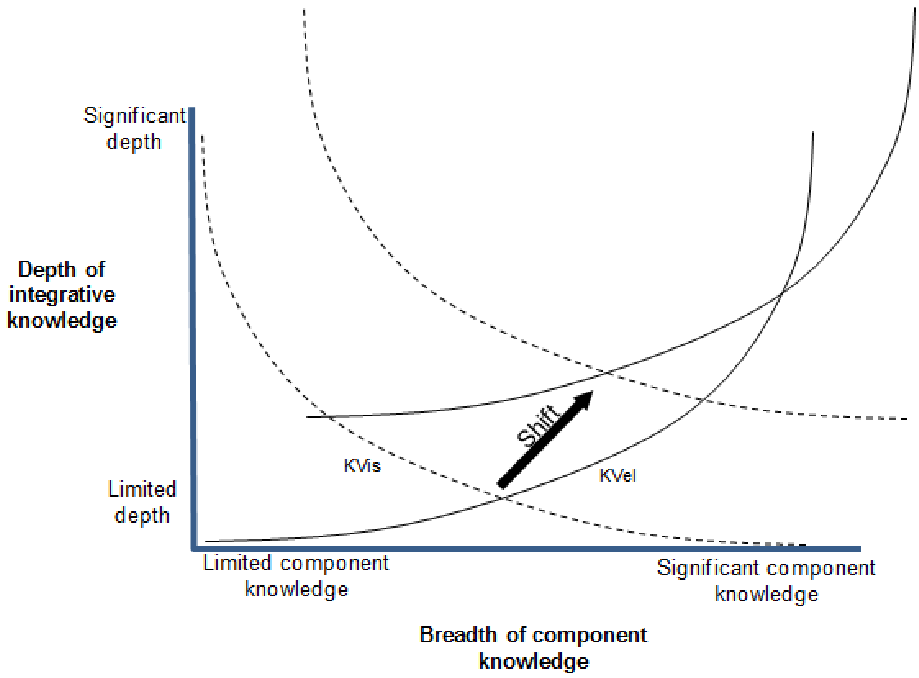
It is clear from the above that intra-level factors are interwoven. For instance, integrative knowledge at one level depends on the component knowledge of the same level. Likewise, inter-level factors are related to each other, as any attempt to increase knowledge about a single component requires a corresponding knowledge increase at lower levels (i.e. in subcomponents). The challenge is even greater when it comes to increasing knowledge about several components.

Graphically, the range of 'balance' options offered to the technology acquirer is represented in Figure 4-3 by the curve labelled "set of combinations". Explained differently, any technology acquirer making the trade-off to increase either depth of knowledge ($KVis_0$) or breadth of knowledge ($KVel_0$) will likely have to move along the same curve represented by the "set of combinations" in Figure 4-3.

Consequently, due to the difficulty of disentangling component knowledge from integrative knowledge, and vice-versa, a **third scenario** can be adopted in order to increase knowledge transferred KT_0 (see (11)). It consists of increasing both depth of knowledge ($KVis_0$) and breadth of knowledge ($KVel_0$), or increasing one of them without decreasing the other.

Because the two factors are inversely proportional, increasing both factors is only possible by achieving a shift like the one represented by the arrow in Figure 4-5. Such a shift is enacted through structural, multi-dimensional and systemic measures that should lead to the establishment of coherent sectoral and national innovation systems (e.g. creating an innovative environment, fostering collective work, improving absorptive capacity of learners) (see chapter 2, section 2.7).

Figure 4-5: Increasing knowledge breadth and knowledge depth



Source: Author.

4.4 Experiential learning model

The experiential learning model proposed in this section applies subsequent to technology transfer from abroad having occurred via collaborative projects. It evaluates locally transferred (or diffused) knowledge in order to build local capabilities. It is a systemic model that evaluates learning processes occurring at and between various local learning levels: individual, group, organisation and inter-organisation (chapter 2, subsection 2.4.2). In a technological context, learning is effective when combining learning by doing, learning by searching, and learning by interacting (chapter 2, subsection 2.4.5). The experiential learning model evaluates the combination of these learning types, at various learning levels, by using Kolb's Experiential Learning Theory[23] and March's concepts of 'exploration' and 'exploitation'.[24] The selection of Kolb's theory is motivated by the fact that this influential theory is grounded in experience and that learning is effective when it is holistic. Fundamentally, this happens when two dimensions, reflection and action, are combined during the learning process.

4.4.1 Formulating the model

Learning is a systemic phenomenon that can be dissected according to vertical and horizontal differentiation.[25] Each learning level (individual, group, organisation or inter-organisation) can be modelled, horizontally, according to a Kolb-like learning cycle (chapter 2, subsection 2.4.2). The term horizontal refers to intra-level learning.

On the other hand, vertical connections are made between the horizontal levels of aggregation by borrowing March's concepts of 'exploration' and 'exploitation'.[26] Vertical connections refer to the cross-level learning.

The proposed systemic experiential learning model is the combination of vertical and horizontal processes.

Intra-level learning (horizontal differentiation)

As discussed in chapter 2 (subsection 2.4.2), learners, whether they be individuals, groups, organisations, or inter-organisations, are more effective when completing Kolb-like cycles. The latter are tension-filled processes where action (i.e. practical aspects) is combined with reflection (i.e. theoretical aspects).

On the other hand, the literature on technological learning identifies three types of learning: learning by doing, learning by searching and learning by interacting (chapter 2, subsection 2.4.5). In a technological context, learning is effective when it combines these three types of learning.

The proposed model draws a parallel between the typology of technological learning (learning by doing, by searching and by interacting) and the combination of action and reflection. Learning by doing can refer to the practical aspects of learning, or what Kolb defines as 'action'. Learning by searching can refer to the theoretical aspects, or what Kolb defines as 'reflection'.

Accordingly, combining learning by doing and learning by searching can be modelled as a Kolb-like cycle combining action with reflection. This intra-level or horizontal combination is enabled by interaction. The technological learning typology identifies the latter as 'learning by interacting'.

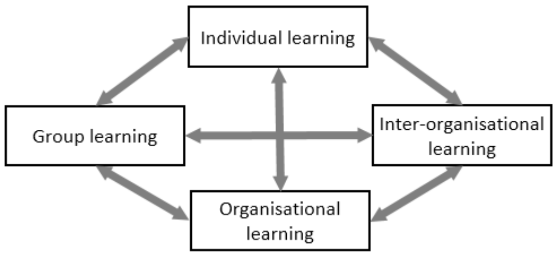
However, interactions occur also between learning levels (individual, group, organisation or inter-organisation). This is why the inter-level dimension is also considered in the proposed model.

Inter-level learning (vertical differentiation)

As mentioned above, learning is a systemic phenomenon where processes that occur at separate levels of aggregation interrelate with each other.[27] In the context of knowledge transfer from developed to developing countries, learning is effective when knowledge is locally diffused and used to develop local capabilities in developing countries. Local diffusion results primarily from the "diffusion of knowledge and/or skill from the individual to members of the collective, and expansion of the collective's capacity to take effective action".[28] It results also where processes at all levels evolve to mutually supportive relationships.[29] This is very often reflected in the local value created.

A number of authors suggest that successful diffusion leads to a systemic phenomenon where the interplay involves all levels of aggregation from individual to inter-organisation.[30] Coghlan[31] and Beeby & Booth[32] illustrate the systemic nature of diffusion through a network-like model (Figure 4-6).

Figure 4-6: Network interaction between all learning levels



Source: adapted from Coghlan, D., 1997. Organizational learning as a dynamic interlevel process. Current topics in management 2, 27-44. And from Beeby, M., Booth, C., 2000. Networks and inter-organizational learning: a critical review. The learning organization 7(2), 75-88.

In the proposed model, diffusion is vertical when it refers to cross-level learning or relationships and horizontal when it refers to learning cycles occurring at each level of aggregation. The current subsection seeks to highlight the elements that underlie the interplay between levels of aggregation (or cross-level learning) as well as the complexity of such relationships.

Indeed, as discussed above, each learning level can be modelled horizontally according to a Kolb-like learning cycle. The proposed approach then is to draw connections vertically between Kolb's learning cycles at each level of aggregation. These connections are made by borrowing March's[33] concepts of 'exploration' and 'exploitation' and by juxtaposing them with Kolb's learning cycles.

Prior to drawing these connections, it is useful to recall that March's concepts of 'exploration' and 'exploitation' are central to the study of adaptive processes.

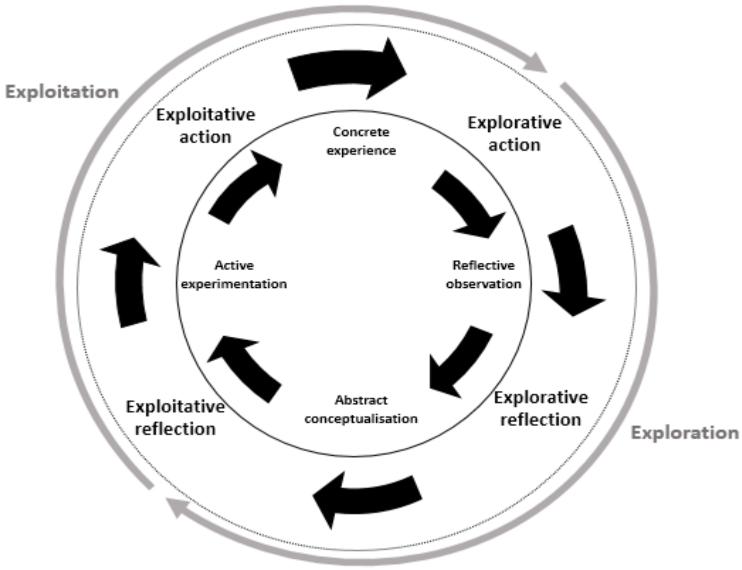
March stresses that the survival of any adaptive system requires an appropriate trade-off between exploration and exploitation. He warns that "systems that engage in exploration to the exclusion of exploitation are likely to find that they suffer the costs of experimentation [i.e. trialling] without gaining many of its benefits ……[*and*] conversely, systems that engage in exploitation to the exclusion of exploration are likely to find themselves trapped in suboptimal stable equilibria".[34]

Building on the concepts of exploration and exploitation, Holmqvist[35] examines the interplay between organisational and inter-organisational learning. He points to the duality in organisational learning, arguing that organisations engage in a process of exploration when they need to create variety in their experiences through experimentation (i.e. trialling) and taking risks, whereas, they engage in a process of exploitation when they need to create reliability in experience by focusing on and refining certain activities. A number of scholars underscore the cyclical relationship between exploration and exploitation and describe how exploration leads to exploitation and vice-versa.[36] Holmqvist[37] argues that the cyclical exploration-exploitation dynamic occurs at the organisational level as well as beyond it – at inter-organisational level, where it orchestrates the interplay between these two levels. He thus proposes a dynamic model of intra- and inter-organisational learning.

Based on the foregoing, the present model draws connections between the two learning cycles: the exploration-exploitation cycle and Kolb's cycle at four levels of aggregation (i.e. individual, group, organisation, and inter-organisation). It proposes a theoretical dynamic model that explains the interplay between levels of aggregation.

For the purposes of this model, exploration refers to the process of a preliminary examination of a subject either in terms of experimentation (i.e. action; or learning by doing) or conceptualisation (i.e. reflection; or learning by searching). Exploitation refers to the process of making use of knowledge through 'mature' conceptualisation (i.e. reflection or learning by searching) or through active experimentation (i.e. action or learning by doing). Therefore, the learning cycle at each level of aggregation can be viewed as a continuous exploration-exploitation cycle, and, when juxtaposed with Kolb's cycle, it provides a four-step cycle (Figure 4-7): explorative action, explorative reflection, exploitative reflection, and then exploitative action.

Figure 4-7: Exploration-exploitation cycle juxtaposed with Kolb's cycle



Source: Author

Explorative action is where learners (e.g. individuals, groups, organisations and inter-organisations) are assigned a task which they then perform (or experience). At this stage the process is still explorative, because learners have not yet internalised what is behind the concrete experience. That is why they need to engage in an explorative reflection, where they step back from the task and reflect on what has been done and explore the experience. Exploration at this stage is carried out through formulating questions and attempting to answer them.

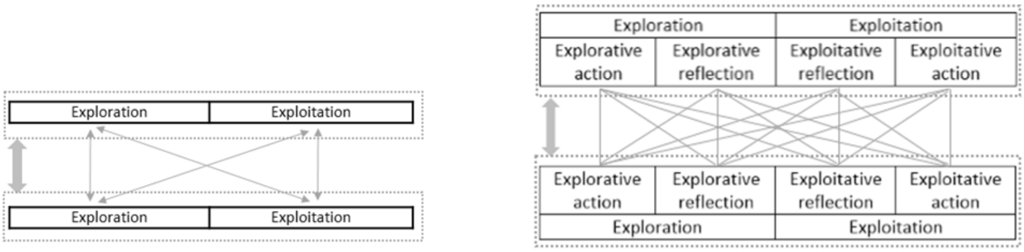
Once reflection has matured (or been refined), learners conceptualise theories and models of what was experienced with the intention of exploiting them or putting them into practice. This stage is called exploitative reflection. Finally, learners attempt to plan how to test their models and theories, and how to enter into a new experience. In general, learners usefully exploit the experience (or the ensuing theories and models) by placing it into a context that is relevant to them. This stage is called exploitative action.

It is clear that any proposed model explaining the interplay between levels of aggregation should illustrate the systemic nature of the learning process.[38] This systemic nature is primarily underpinned by the relationships between each pair of learning levels of aggregation. For Isaac,[39] dialogue is of essence to collective thinking and learning. He defines dialogue as "a sustained collective inquiry into the processes, assumptions, and certainties that compose everyday experience".[40]

Based on this definition, the present model posits that learners, whether they be individuals, groups, organisations, or inter-organisations, trigger intra-level and cross-level dialogues during learning. The intra-level dialogue occurs at the same level of aggregation and is represented through learning cycles (Figure 4-7). The cross-level dialogue is triggered between levels of aggregation and is represented in Figure 4-8.

The complexity of cross-level relationships is illustrated by the multitude of dialogue types or connections that any pair of learning levels can establish. In each pair, each level reciprocally affects the other (or internalises from the other). Both levels are tied together through the following simplified combinations: exploitative-exploitative, exploitative-explorative, explorative-explorative, and explorative-exploitative (Figure 4-8a); or the full-length combinations: exploitative action-exploitative action, exploitative action-exploitative reflection, …, explorative action-explorative action (Figure 4-8b). Table 4-2 lists all dialogue combinations identified by the proposed model, together with their meaning in the context of technological learning.

Figure 4-8: Interplay between each pair of learning levels



(a) (b)

Source: Author

Table 4-2: Inter-level dialogue combinations

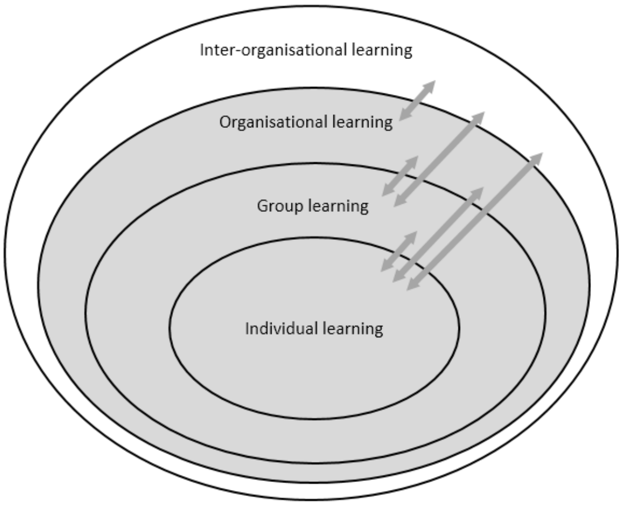
General combinations	Detailed combinations	Meaning in the context of technological learning
Exploitative-Exploitative	Exploitative action-Exploitative action	**Dialogue between** learner who (regularly) performs practical tasks (e.g. manufacturing tasks) or matures conceptually the tasks (e.g. mature design) **and** learner who (regularly) performs practical tasks (e.g. manufacturing tasks) or matures conceptually the tasks (e.g. mature design)
	Exploitative action-Exploitative reflection	
	Exploitative reflection-Exploitative action	
	Exploitative reflection-Exploitative reflection	
Exploitative-Explorative	Exploitative action-Explorative action	**Dialogue between** learner who (regularly) performs practical tasks (e.g. manufacturing tasks) or matures conceptually the tasks (e.g. mature design) **and** learner who tests and explores practical tasks (e.g. laboratory experience) or conceptual ideas (e.g. research)
	Exploitative action-Explorative reflection	
	Exploitative reflection –Explorative action	
	Exploitative reflection-Explorative reflection	
Explorative-Explorative	Explorative action-Explorative action	**Dialogue between** learner who tests and explores practical tasks (e.g. laboratory experience) or conceptual ideas (e.g. research) **and** learner who tests and explores practical tasks (e.g. laboratory experience) or conceptual ideas (e.g. research)
	Explorative action-Explorative reflection	
	Explorative reflection –Explorative action	
	Explorative reflection-Explorative reflection	
Explorative-Exploitative	Explorative action-Exploitative action	**Dialogue between** learner who tests and explores practical tasks (e.g. laboratory experience) or conceptual ideas (e.g. research) **and** learner who (regularly) performs practical tasks (e.g. manufacturing tasks) or matures conceptually the tasks (e.g. mature design)
	Explorative action-Exploitative reflection	
	Explorative reflection–Exploitative action	
	Explorative reflection-Exploitative reflection	

Source: Author

The reciprocal effect between levels of learning also depends on their ability to interact. This ability can be explained by borrowing Hamel's[41] concepts of 'transparency' and 'receptivity'. In this model, 'transparency' refers to the openness of a learning level (individual, group, organisation, or inter-organisation) to other levels by sharing experiences with them, and 'receptivity' refers to the ability to absorb knowledge that comes from other levels by internalising their experiences. Holmqvist[42] employs these concepts to explain the relationship between organisational and inter-organisational levels. The present model advocates generalising the use of these concepts to explain relationships between all levels of aggregation (individual, group, organisation and inter-organisation).

The reciprocal effect between levels of learning reflects the systemic nature of learning and shows that the phenomenon transcends learner boundaries, whether learners be individuals, groups, organisations or inter-organisations. However, illustrating learning's systemic nature in the form of networks (Figure 4-6) with a broad variety of possible combinations between levels of learning (Figure 4-8) does not necessarily imply intense cross-level interactions. Indeed, network-like representation seems to neglect the significance of 'vertical' barriers. These come about as a result of hierarchical relations[43] between organisational levels plus "the complexity with which a given system level is organized, the size in physical space of its constituent units, the physical proximity of these units, their characteristics, and the distinctive structures and processes characterizing these units".[44] Figure 4-9 illustrates the interplay between learning levels and depicts the hierarchical aspect. The shaded area in this figure reveals that hierarchy is dominant in the intra-organisation context.

Figure 4-9: Interplay between hierarchical learning levels

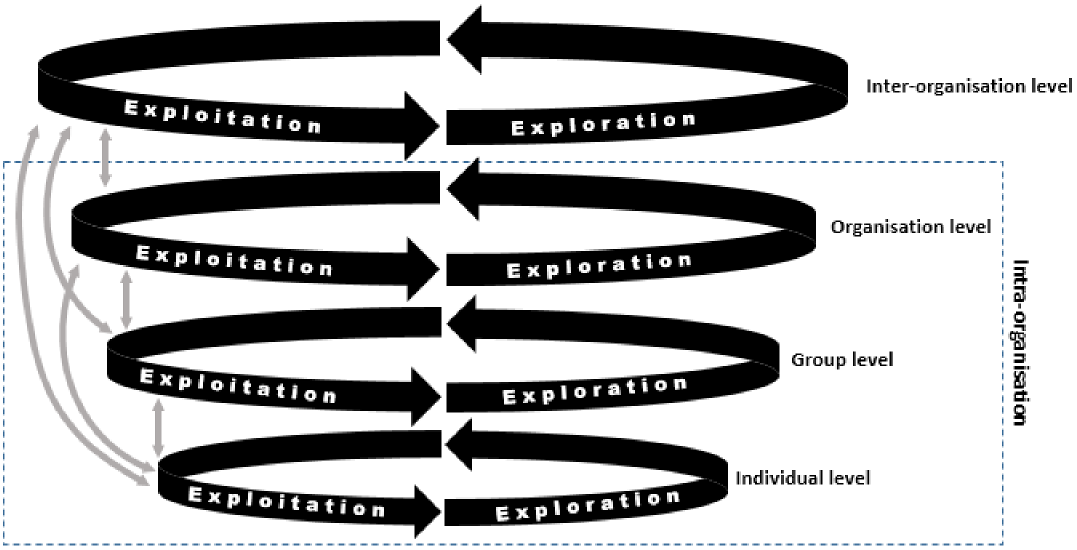


Source: Author

Another argument in favour of choosing a hierarchical model to capture the systemic nature of learning is the presence of forms of authority (formal and informal) at the intra-organisational level (individual, group and organisation). Such forms of authority can hinder cross-level or 'vertical' learning. Paradoxically, according to experiential learning theory, in order to make learning intentional, there is a need for coordinating authorities at each level of learning. These authorities drive and orchestrate the 'horizontal' learning cycles and balance between action and reflection[45] or between exploration and exploitation.[46] The lack of such authorities at inter-organisational level is a major barrier to learning, as several studies have revealed.[47]

Indeed, a great deal of the systemic learning lies in the paradoxical effect of these authorities (hindering vs driving). Through these authorities, conditions and behaviours are aligned within and across different levels of aggregation,[48] and learning curves can be shortened.[49] Figure 4-10 illustrates the key components of the proposed model by representing horizontal and vertical differentiations (i.e. horizontal learning cycles and the vertical arrows connecting them through concepts of exploitation and exploration), along with considerations related to hierarchy (i.e. learning levels).

Figure 4-10: Experiential learning model



Source: Author

4.5 Evaluation metrics at micro, meso and macro levels

The categories of evaluation metrics described in section 4.1 (Table 4-1) are formed of metrics spread across different analysis levels: macro, meso and micro. These metrics are summarised in Tables 4.3, 4.4, and 4.5, respectively.

Table 4-3: Macro level evaluation metrics

Categories	Metrics	
Metrics related to Technological Learning (M.T.L)	**Velocity-viscosity and architecture-component balance**	Intensity of interactions between organisations involved in satellite development Degree of involvement of these organisations Number of system components outsourced Depth of development of outsourced components through the ratio: number of individuals involved / number of individuals required
	Absorptive capacity	Level of inter-organisational prior knowledge (previous inter-organisational experience, preparatory inter-organisational activities) Intensity of inter-organisational effort (inter-organisational objectives, and degree of achievement)
	Inter-organisational learning	Number, intensity and nature of activities between organisations Alignment of inter-organisational activities (and objectives) with organisational, team and individual activities
	Combination of learning by doing, learning by searching and learning by interacting	Number and intensity of practical activities (engineering and development) between organisations Number and intensity of theoretical activities (research) between organisations Connections between practical and theoretical activities
	Explicit-implicit balance	Intensity and nature of interactions between organisations Inter-organisational documentation and material produced and shared (inter-organisational memory) Employment stability (personnel turnover)
Metrics related to locally built Technological Capabilities (M.T.C)	**Inter-organisational capabilities**	Physical investment at inter-organisational level: equipment (heavy and shared between organisations), machinery, physical facilities Human capital Information (inter-organisational documentation) Management capabilities (inter-organisational coordination, communication, planning, incentives, risk, quality assurance)
	Sophistication level of inter-organisational capabilities	Simple capabilities for exploitation activities (operations) Intermediate capabilities for engineering and development activities Advanced capabilities for research and innovation activities Connections between engineering, development and research activities
Metrics related to Transferred Technology (M.T.T)	**Technology components transferred from abroad**	Object-embodied technology, inter-organisational level equipment, machinery, physical facilities Document-embodied technology (inter-organisational documentation)
	Maturity and sophistication level of transferred technology at inter-organisational level	Old, established, sophisticated Simple, intermediate or advanced
	Transferor-transferee relationship	Interaction between organisations of the transferor's supply chain with the transferee or organisations of the transferee's supply chain
	Appropriateness of technology transfer mechanism	Interaction between organisations of the transferor's supply chain with the transferee or organisations of the transferee's supply chain
	Management practices that foster learning culture	Transferee strategies and entities in charge of learning promotion at inter-organisational level Training programmes on small satellite management at international level

Source: Author

Table 4-4: Meso level evaluation metrics

Categories	Metrics	
Metrics related to Technological Learning (M.T.L)	**Velocity-viscosity and architecture-component balance**	Intensity of interactions between groups of the same organisation Degree of involvement of these groups Number of system components insourced Depth of internal development through the ratio: number of individuals involved / number of individuals required
	Absorptive capacity	Level of organisational prior knowledge (previous organisation experience, preparatory organisational activities) Intensity of organisational effort (organisational objectives and degree of achievement)
	Organisational learning	Number, intensity and nature of activities between groups of the same organisation Alignment of organisational activities (and objectives) with inter-organisational, team and individual activities
	Combination of learning by doing, learning by searching and learning by interacting	Number and intensity of practical activities (engineering and development) between groups of the same organisation Number and intensity of theoretical (research) activities between groups of the same organisation Connections between practical and theoretical activities
	Explicit-implicit balance	Intensity and nature of interactions between groups Organisational documentation and material produced and shared (organisational memory) Employment stability (personnel turnover)
Metrics related to locally built Technological Capabilities (M.T.C)	**Organisational capabilities**	Physical investment at organisational level: equipment, machinery, physical facilities Human capital Information (organisational documentation) Managerial capabilities (inter-group management practices, empowerment, coordination, communication, planning, incentives, risk, quality assurance)
	Complexity degree of organisational capabilities	Simple capabilities for exploitation and operational activities Intermediate capabilities for engineering and development activities Advanced capabilities for research (innovation), specification and design activities Connections between engineering, development and research activities
Metrics related to Transferred Technology (M.T.T)	**Technology components transferred from abroad**	Object-embodied technology, organisational level equipment (heavy and shared within the organisation), machinery, physical facilities Document-embodied technology (organisational documentation)
	Maturity and sophistication level of transferred technology at organisational level	Old, established, sophisticated Simple, intermediate or advanced
	Transferor-transferee relationship	Objectives of the transferee organisation International experience of the transferee organisation Coordination and interaction between both organisations, the transferor and transferee
	Appropriateness of technology transfer mechanism	Interaction between both organisations, the transferor and transferee Contractual flexibility to technology transfer Project control Risk management approach
	Management practices that foster learning culture	Transferee strategies and entities in charge of learning promotion at organisational level Training programmes on small satellite management at organisational level

Source: Author

Table 4-5: Micro level evaluation metrics

Categories	Metrics	
Metrics related to Technological Learning (M.T.L)	**Velocity-viscosity and architecture-component balance**	Intensity of interactions between individuals and project sub-teams (of the same team) Degree of involvement of these individuals and sub-teams Number of system subcomponents insourced Depth of internal development through the ratio: number of individuals involved / number of individuals required
	Absorptive capacity	Level of individual and team prior knowledge (educational and professional background, previous individual and team experience in satellite development, appropriateness of prior knowledge to satellite development, preparatory individual and team activities for satellite projects) Intensity of individual and group effort (individual and group objectives and degree of achievement)
	Individual and group learning	Number, intensity and nature of activities between individuals and sub-teams of the same team Alignment of individual and team activities (and objectives) with inter-organisational and organisational activities
	Combination of learning by doing, learning by searching and learning by interacting	Number and intensity of practical activities (engineering and development) between individuals and sub-teams of the same team Number and intensity of theoretical (research) activities between individuals and sub-teams of the same team Connections between practical and theoretical activities
	Explicit-implicit balance	Activities of mentoring (intensity, duration) Theoretical and practical training Intensity and nature of the interactions between individuals Individual and team documentation and material produced and shared (individual and group memory) Employment stability (individual and team stability, personnel turnover)
Metrics related to locally built Technological Capabilities (M.T.C)	**Individual and team capabilities**	Physical investment at individual and team level: equipment (light), machinery, tools, physical facilities Human capital: individual and team skills Information (individual and team documentation) Management capabilities (individual and team empowerment, planning, incentives, risk)
	Sophistication level of individual and team capabilities	Simple capabilities for exploitation and operational activities Intermediate capabilities for engineering and development activities Advanced capabilities for research activities Connections between engineering, development and research activities
Metrics related to Transferred Technology (M.T.T)	**Technology components transferred from abroad**	Object-embodied technology, individual and team level equipment, machinery, tools, physical facilities Person-embodied technology: individual and team skills, exposure time to technology Document-embodied technology (individual and team documentation) Management skills transferred at individual and team level
	Maturity and sophistication level of transferred technology at individual and team level	Old, established, sophisticated Simple, intermediate or advanced
	Transferor-transferee relationship	Objectives (and motives) of the transferee individuals and teams International experience of the transferee individuals and teams Languages proficiency of the transferee individuals Communication skills of the transferee individuals Coordination and interaction between individuals and teams from both sides, the transferor and transferee
	Appropriateness of technology transfer mechanism	Joint management of collaborative projects Interaction between individuals and teams from both sides, the transferor and transferee Individual and team learning activities covered by the mechanism (practical, theoretical, mentoring) Individual and team involvement in the project phases
	Management practices that foster learning culture	Learning incentives at individual and team level

Source: Author

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Chapter 5: Research Methodology

Research methodology refers to the theoretical considerations underpinning the process of conducting research. It provides insight into how the research aim connects with the research methods.[1] Connecting aims with methods reflects the systematic character of research. The strengths and weaknesses of these connections determine the quality of the research. Hence, this chapter explains the rationale behind the methods employed in this study. The present research falls within the field of business and management. The starting point of the discussion is to recognise the trans-disciplinary nature of this field, and to point out the various methodological options available for conducting research.

In order to reconcile the necessity for investigation in this field with the inevitable constraints faced (i.e. time, access to data, funding and location), there is a need to position the present research. The positioning, which delimits areas of investigation, is addressed in section 5.1.

Section 5.2 sets the discussion within the debate of philosophical schools in the social sciences, and highlights the role of foundational theories in outlining the research design. In addition, section 5.3 offers insights into the methodological options commonly used in the evaluation research, particularly in the context of developing countries.

Section 5.4 then builds on the foregoing discussion and suggests a methodological framework (i.e. research design) for addressing the research aim. It discusses also how ethical and quality considerations bear on the research.

5.1 Research positioning

The present research is tackled from three major perspectives, represented by the Venn diagram in Figure 5.1. The confluence of the circles illustrates the positioning of the research at the crossroads of three scientific realms: ‘space’

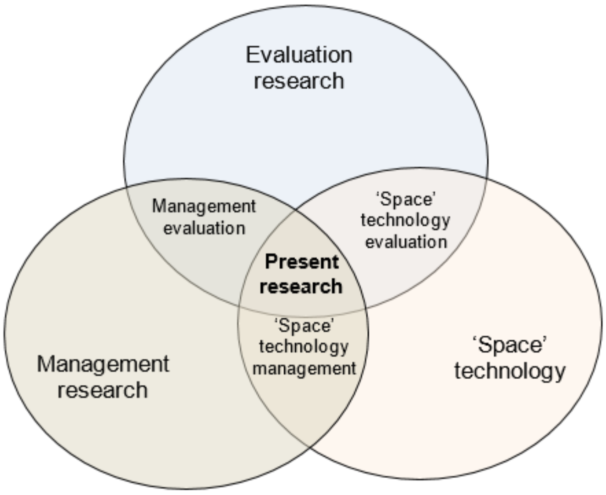
[1] Research methods refer to data collection and analysis techniques and procedures.

technology, management research and evaluation research. This positioning underpins discussion of the nature of the research and methods used.

The management research circle denotes academic research on topics relevant to the field of management. The focus is on aspects that have a social science orientation, including both intellectual traditions and practical considerations. The ‘space’ technology circle symbolises space technology *per se*. It refers in a broader context to knowledge-intensive industries that are of relevance to developing countries. The intersection of both circles represents the set of management disciplines that allows organisations to manage their technological ‘capital’, commonly known as management of technology.[1]

The third circle is that of evaluation research. It designates academic research that draws on methodologies and methods of the social sciences in the realm of evaluation. The intersection of the latter circle with each of the other two identifies the types of evaluation conducted during this study: management evaluation[2] and ‘space’ technology evaluation.[3] The set of crosscutting perspectives which lie at the confluence of all three circles in Figure 5-1 informs about the methodological choices available to conduct the present research.

Figure 5-1: Positioning of the research



Source: Author

The diversity of perspectives from which the present research is conducted brings the discussion back to the trans-disciplinary nature of business and management research.[4] It raises the idea that the knowledge obtained concurrently from a range of disciplines enables new insights to be gained that are not afforded by assuming a separate-discipline perspective.[5]

5.1.1 Reconciling theoretical rigour with practical relevance

The present management research includes a significant component of evaluation research. Practical relevance and action-oriented[6] are aspects the present research seeks to satisfy; notably since the funding organisation which commissioned the present research, namely Algeria’s space organisation, expects practical impact.

Indeed, in addition to embracing practical imperatives, the present doctoral research needs to be built on rigorous methodological and theoretical foundations. This naturally leads into reviewing the general debate on how management research in academia ties in with practice and the emergence of an alternative paradigm reconciling the dual imperatives of theoretical and methodological rigour with those of practice relevance.

According to Gibbons et al.,[7] theoretical imperatives are more often associated with research conducted by detached scientists working on theoretical questions from a mono-disciplinary perspective. The authors refer to it as mode 1 research. By contrast, practical imperatives are associated with trans-disciplinary research, producing practically meaningful knowledge. Gibbons et al.[8] describe this as mode 2 research. The alternative paradigm consists in adopting an intermediate way that combines the strengths of the two traditional paradigms and bypasses their weaknesses – described as mode 1.5 research.[9]

This third way is advocated by a number of scholars[10] endeavouring to achieve a paradigm shift by questioning the outcomes of academic research. These scholars consider the requirements of all stakeholders, both inside and outside the world of academia (e.g. academics, practitioners, managers, policy makers, consumers and financiers). They especially take into account concerns about the divide between researchers in academia and practitioners.

The suggested compromise is called ‘pragmatic science’, as illustrated in Table 5-1. It corresponds to knowledge production simultaneously seeking high practical relevance and high theoretical and methodological rigour.

Table 5-1: Typology of research

		Theoretical and methodological rigour	
		Low	**High**
Practical relevance	**High**	Popularist science	Pragmatic science
	Low	Puerile science	Pedantic science

Source: adapted from Hodgkinson, G.P., Herriot, P., Anderson, N., 2001. Re-aligning the Stakeholders in Management Research- Lessons from Industrial, Work and Organizational Psychology. British Journal of Management 12, S41–S48.

The present research is categorised under the “pragmatic science” paradigm. Conducting research within this paradigm rests mainly on the nature and intensity of exchange between stakeholders during the research process – from the outset to the outcome.[11] It hinges on the researcher’s ability to combine methodological skills needed to conduct academic research with socio-political skills needed to interact with various stakeholders (i.e. convince both the academic and practitioner communities).[12]

The present researcher’s educational and professional background,[13] the full-time mode under which this doctoral research was undertaken and the support of Algeria’s space organisation have proven invaluable in seeking convergence between theory and practice in this research.

5.1.2 Research ambition

The present research aims to address a particular problem within a particular context by seeking to discover facts from empiricism. Therefore, it may be classed as an applied-empirical research rather than basic and non-empirical research.[14]

From the applied research perspective (and unlike basic research that aims to discover new knowledge), the present research has the primary purpose of applying existing knowledge in the field of management (of technology) and evaluation research to the poorly researched topic of small satellite capability-building in developing countries (taking Algeria as a case study).[15]

'Local' knowledge[16] developed within this research focus is considered a contribution to knowledge.[17] The contribution lies mainly in empiricism by collecting data using a wide variety of social research methods.

5.2 Decisions underpinning the research design

Choosing suitable methods requires an appreciation of their strengths and weaknesses in order to formulate a sound research design capable of generating meaningful findings. Using inappropriate methods might produce contradictory findings, leading to ambiguous or confusing recommendations.[18]

To ensure research validity, it is vital that an informed choice of methods is made through an understanding of the underlying philosophical and methodological considerations. The following subsections discuss these considerations, that are then applied to make an informed choice in section 5.4.

There is a great deal of debate between different schools of thought expounding varied philosophical and methodological views on business and management research. Saunders et al.[19] and Easterby-Smith et al.[20] use two frameworks-cum-metaphors, the 'research onion' and the 'trunk cross-section' respectively, to map the layered landscape of these debates.

The framework proposed by Saunders et al.[21] stratifies the elements to be considered during the research design as an onion layers. The starting point is the outer layer, corresponding to the research philosophy. Then, the progressive peeling of the onion reveals subsequent layers, standing in for a succession of research approaches, methodological choices, and strategies. Finally, the core of the onion corresponds to data collection and analysis techniques and procedures.

By contrast, Easterby-Smith et al.[22] stratify elements in reverse order, taking their starting point to be a tree-trunk core corresponding to a set of ontological assumptions, then, moving outwards, there follow layers representing epistemological assumptions, methodological choices, and finally an outer layer that corresponds to methods and techniques.

The combination of these two metaphorical structures, shown in Figure 5-2, can inform hierarchical decision-making underlying the proposed research design. Figure 5-2's three upper layers specify the philosophical considerations that help the researcher to ground conceptually his research. The three layers that follow address methodological issues that guide inquirer logic, which will lead to the methods selection represented by the lowest layer.

Subsections 5.2.1 to 5.2.7 discuss each layer of the decision hierarchy. The top-down hierarchy (typical of conceptually-oriented research) is proposed only to guide discussion, because sometimes research is methods-oriented, adopting a bottom-up or even mixed approach.[23]

Figure 5-2: Hierarchy of decisions underpinning business and management research design

Philosophical considerations	Layer 1: Fundamental assumptions	Ontology | Epistemology | Axiology
	Layer 2: Research philosophies	Positivism | Realism | Interpretivism | Pragmatism
	Layer 3: Research approaches	Deduction | Induction
Methodological considerations	Layer 4: Methodological choices	Quantitative methods | Qualitative methods | Mixed method
	Layer 5: Research strategies	Experiment | Survey | Archival research | Case study | Ethnography | Action research | Grounded theory | Narrative inquiry
	Layer 6: Time horizons	Cross-sectional | Longitudinal
Methods	Layer 7: Data collection methods	Sampling | Secondary Data | Observation | Interview | Questionnaire

Source: Adapted from Saunders, M., Lewis, P., Thornhill, A., 2012. Research methods for business students. 6th Edition, Pearson Education Limited, p.128. and from Easterby-Smith, M., Thorpe, R., Jackson, P., 2012. Management research. Forth Edition, SAGE Publications Ltd, p.18.

5.2.1 Fundamental assumptions

Data collected in the course of the research are a means of addressing the research aim, not its outcome per se. The chosen data collection techniques should thus form part of a larger coherent picture that speaks to the nature and academic legitimacy of the study. This picture results from an intellectual exercise the researcher must conduct. The exercise is triggered by the researcher questioning their own assumptions.

Fundamental assumptions that influence the researcher's approach are those concerning the 'nature of reality', 'acceptable knowledge' and the 'role of values'. The first is the concern of the branch of philosophy called ontology, the second is the concern of epistemology, and the third is the concern of axiology. Generally, researchers build their research plan on ontological, epistemological and axiological positions that are consciously or unconsciously adopted.

Saunders et al.[24] discuss two major aspects of ontology that are of interest to business and management researchers: objectivism and subjectivism. The ontological position that relates to objectivism is based on the assumption that social entities exist and evolve independently, and are not influenced by social actors. This assumes that the management of social entities tends towards formal, descriptive and prescriptive aspects. On the other hand, subjectivism claims that social phenomena are the result of social actor actions, and are thus viewed through a social actor prism. This assumes that social entities are continuously changing, and management is achieved through an understanding of social actor perceptions and interactions.

With regard to the epistemological position, Bryman & Bell[25] ask the central question of whether the knowledge produced by business and management research is the result of the same principles, procedures and ethos as used in the natural sciences, or whether it is the result of a different research logic that reflects the human and social dimension inherent in business and management research.

For the axiological position, Creswell[26] outlines the proximity during the research process between the researcher and the research subject, and the influence of researcher values on the study. The question then arises as to whether the study is value-free and unbiased or value-laden and biased?

5.2.2 Research philosophies

Even though ontological, epistemological and axiological research assumptions have changed over time, two major paradigms remain as constants in the debate over competing philosophical frameworks: positivism and interpretivism.

Positivism and Interpretivism

Positivism is the oldest and best established paradigm in research.[27] It has been built on natural science assumptions, such as independence of reality from actors and existence of theories that explain phenomena and predict outcomes. Patterns found in data help discover causal relationships between variables, leading to ‘universal’ laws enabling generalisations (in natural science) or law-like generalisations (in social science).

Just as in natural science, where theories are built or tested from factual observation, in social science, theories should be built and tested from real social facts. The concept of testing a theory is mainly associated with positivism. Indeed, any theory, once developed, is destined to grow, expand, be refined or crumble. This evolution is enabled by continually developing hypotheses using existing theory, collecting data and confronting hypotheses with actual results. These tests might confirm or refute theory, partially or totally.

Social scientists are encountering growing complexity and diversity in their research. They need to consider human subjectivity. The use of traditional positivist methods, dealing with physical-world inanimate objects,[28] has been challenged by social scientists, and the interpretivism paradigm has emerged.

Interpretivism is rooted in assumptions that favour the subjectivist ontological position where social actor actions, interactions and perceptions are central in understanding social phenomena. From an epistemological standpoint, in order to come to grips with complexity and uniqueness, it is imperative to adopt 'qualitative' methods. The axiological position of an interpretivist researcher is that values are inextricably linked to facts, and the researcher should be aware of such sources of bias.[29]

Realism and Pragmatism

Positivism and pragmatism are paradigms which can be situated at opposite ends of the continuum of philosophical paradigms. Realism and pragmatism are two other philosophical positions relevant to business and management research[30] that can be situated along the same continuum.

Realism is close to positivism. As with positivism, it adopts an ontological position that refers to objectivism. However, it makes a distinction between direct and critical realism. The former considers that reality can be reached directly by using appropriate methods; the latter considers that the only reality perceived is the result of actor interpretation and thus remains socially conditioned.

The critical realist's position is more relevant to business and management research.[31] It recognises, for instance, the value of multi-level study (e.g. individual, group, and organisation). The latter allows the capture of various levels of perception, in line with the reality of business and management entities.

Pragmatism is one of the most prominent paradigms in business and management research. It gathers philosophical views that can be positioned in the middle of the positivist-interpretivist continuum. Pragmatists claim that due to the complex and dynamic nature of the real world, no single paradigm can provide an adequate philosophical framework for research. Hence, the main driver of research should be the research question itself.

Pragmatists shape their philosophical position from assumptions that combine multiple objectivist and subjectivist views. They switch between views according to their need. They make use of both natural and social science methods (quantitative and qualitative) to produce acceptable knowledge. Their research is value-laden, as subjectivist views nourish every assumption.

In business and management research, pragmatism provides the flexible philosophical stance required by the majority of researchers in this field.[32] Production of practically meaningful knowledge is crucial.[33] Therefore, it is imperative that pragmatically oriented research satisfy this requirement.[34] Combining multiple points of view allows the production of more accurate and applicable knowledge on management entities.

In knowledge management, for instance, pragmatism has considerably affected organisation learning theories.[35] The pragmatic stance adopted in Kolb's Experiential Learning Cycle[36] can be cited as an example of this (i.e., reconciling tangible and observable aspects with intangible and reflective ones).

Finally, it is essential to recall the historical context in which all paradigms emerge. Interpretivism emerged out of a critique of positivism. Both realism and pragmatism can be seen as a combination of elements from interpretivism and positivism. This means that these paradigms share more similarities than differences. Any dichotomy is therefore false and finds its justification in the misconceptions and misclaims advanced by the devotees of each school of thought.[37]

5.2.3 Research approaches

Doctoral research has to be built on sound theoretical underpinnings. Relations between research and theory are critical. These relations are represented by two major approaches: induction and deduction. Their adoption is dictated by the research question, along with the theoretical knowledge available on the subject.

In the deductive approach, the researcher embraces an *a priori* perspective by formulating new hypotheses from established theories and then testing, often empirically, the validity of these theories. If the test is positive, then theory is confirmed (or enriched), otherwise, it is discarded.

In contrast to the deductive approach, the inductive approach argues for an *a posteriori* perspective to conducting research. With induction, researchers start by gathering facts on phenomena through empirical observation. Then, from this limited sample of facts, they try to generate general theories. Considering the uniqueness of situations in business and management research, any generalisation attempt should be viewed with caution.[38]

Similarly, with philosophical research paradigms, boundaries are not sharply drawn between research approaches. Induction and deduction are regarded as two parts of the same whole. In business and management research, they are often combined and not necessarily in equivalent proportions, as one or the other approach frequently predominates.[39] Their combination is even characteristic of sound research in this field.[40]

5.2.4 Methodological choices

This subsection represents the gateway between the philosophical considerations that underpin research design and the non-philosophical (or methodological) considerations that underpin design operationalisation. As mentioned earlier, the nature of the research question and the theoretical knowledge available on the subject determine whether the study will be theory-testing or theory-generative. These two logics are often referred to as quantitative and qualitative research design.

Quantitative research

Quantitative research design is generally associated with the way researchers attempt to operationalise the deductive approach. It is wedded to numerically measurable data. In business and management research, numerically measurable data can be “pure” quantitative data (e.g. age, salaries, and product volume) or “quantitised” qualitative data (e.g. subjective elements, opinion or feeling that are mapped to a numerical scale). Thus, quantitative research can include elements from interpretivist philosophy and the inductive approach.

Qualitative research

Researchers opt for qualitative design when seeking to operationalise the inductive approach. They collect non-numerical data and analyse them to gain an understanding of the influence of social actors and social context. Non-numerical data collected in qualitative research can be "quantitised" and then analysed statistically. Thus, qualitative research can include elements from quantitative research.

Mixing quantitative and qualitative research

In business and management research, the recommended practice is to avoid exclusivism or dichotomy. The prevailing trend is towards combination of quantitative and qualitative elements in the same piece of research.[41]

This form of design falls under the umbrella of the so-called mixed methods research design. It draws from philosophical positions that combine elements of positivism and interpretivism. Realism and pragmatism are the philosophical stances that most likely lead to this form of design.[42] Quantitative and qualitative methods can be fully or partially integrated during data collection and analysis processes. A multitude of mixture variants[43] can be designed. They make use of a range of mixed strategies according to the constraints that might be faced (e.g. timing, access to data) and the nature of the research.

Research nature

The research nature generally derives from the research purpose.[44] Collis & Hussey[45] identify four types of research. Research is exploratory when the subject is poorly studied. The purpose of this type of research is to gain insight and knowledge about the subject. Research is descriptive when its purpose is to describe thoroughly the studied phenomenon by featuring and informing, in detail, its characteristics. The third type of research is analytical, also referred to as explanatory. It aims to go beyond describing phenomena and attempts to provide explanations. This occurs through analysing and explaining relationships between the problem variables so as to establish causal relationships. The last type of research is predictive. It aims to go beyond explaining phenomena and establishing causal relationships. It makes use of the research findings in particular situations in order to predict outcomes of other similar situations. Predictive studies are at the centre of the debate on generalisation in the social sciences.

It should be noted that whether the study is exploratory, descriptive, analytical or predictive, both quantitative and qualitative methods are applicable through a range of strategies.

5.2.5 Research strategies

Based on methodological considerations, a research action plan is proposed. It is referred to as the research strategy. Numerous strategies are thought of as appropriate for social research. Eight of them are traditionally used (and well documented) within the management environment.

Two of the strategies (experimental study and survey) relate to quantitative research. Four others (ethnography, action research, grounded theory, and narrative inquiry) are associated with qualitative research. The two remaining (archival research and case studies) are associated with quantitative, qualitative and mixed design. Needless to mention that despite these commonplace associations, the strategies can be used in any form as long as coherence is assured in the design.

Experimental study and survey

Experimental study is a strategy used to seek causal relationships amongst the variables of a phenomenon. The principle is to identify the change in one variable (i.e. the dependant variable) in response to change in or manipulation of other variables (i.e. independent variables).

Experiments in business and management are almost never pure or true. They deal with unpredictable facets of human behaviour that make it hard to meet control requirements. Sample selection and experimental context (e.g. location, time) are two other major aspects that affect an experiment's validity.

Plenty of quantitative business and management research seeks to find causal relationships between variables starting from non-predicted outcomes (i.e. in the absence of a hypothesis). Many other studies seek explanations and look for generalisation, or simply aim to describe a phenomenon. They often use a survey strategy. In the latter, data are collected from representative samples of the population.

Traditionally, a survey strategy is in line with the positivist stance (i.e. large sample and generalisation). However, as every strategy has to be adjusted according to the research purpose, many variants of the survey rest on an interpretivist position (i.e. small sample, case-oriented).

Ethnography, action research, grounded theory and narrative inquiry

Ethnography is the earliest strategy associated with qualitative research.[46] Its roots lie in anthropology, and it is used to study people's interactions in groups. Ethnographers focus on the study of actor interactions through immersion in their environment to gain a deeper and more nuanced understanding. The most popular data collection technique used by ethnographers is participant observation.

The next earliest strategy associated with qualitative research is action research.[47] It focuses on addressing and resolving problems faced by organisations. It involves a researcher entering an organisation and progressively and iteratively conducting an inquiry. This process fosters organisational learning and promotes problem resolution from within the organisation.

The third strategy associated with qualitative research is grounded theory.[48] It is used to generate theoretical explanations of phenomena by exploitation of a wide range of data. The process starts inductively by collecting data in order to develop an initial theoretical framework. This is then deductively tested. A back-and-forth process between inductive and deductive reasoning continues as long as it enriches the theoretical framework.

Narrative inquiry is another strategy used in qualitative research. Unlike grounded theory, which requires an analytical fragmentation during data collection, narrative inquiry considers that any predefined fragmentation may cause a loss in data richness. It suggests that participant experiences are better captured if the participants narrate them as stories within their own context and chronology (rather than being framed by questions, for instance).

Archival research and case studies

Archival research is a strategy that analyses primary and secondary data available in the public domain, such as government statistical databases, or non-public domain, such as government and company records.

The case study is a strategy that studies phenomena within their context. It is used when there is no clear delineation between phenomena and context. Context is often underpinned by the interpretivist position. Data collection, on the other hand, is guided by the development of an *a priori* theoretical framework (positivist position). Due to this duality, the case study strategy adopts either a quantitative, qualitative or mixed design. It prescribes the use of several data collection techniques (i.e. triangulation) in the same research project for capturing qualitative and quantitative aspects.

Several variants[49] of case study design are identified in business and management research. Their adoption is mainly contingent upon the number of cases to study, the unit of analysis, and the context/case balance (i.e. to what extent is the context considered when studying the case).

5.2.6 Time horizons

Another fundamental question that needs to be addressed is whether data will be collected at a particular time (i.e. a single snapshot of the phenomenon) or over a period of time (i.e. multiple snapshots of the phenomenon). Studies that rely on a single snapshot are referred to as cross-sectional. Analysis outcomes are drawn out from time-limited factual observations. Studies relying on multiple snapshots are referred to as longitudinal. Outcomes might bring out the phenomenon's tendencies and evolution and reveal one-off events as observations spread over time.

In business and management research, both cross-sectional and longitudinal studies employ quantitative, qualitative, and multiple research strategies. Moreover, cross-sectional study may incorporate longitudinal study elements and vice-versa.

5.2.7 Data collection methods

The research plan is completed through the selection of data collection methods. In practice, these can be employed with various research strategies and be underpinned by various philosophical stances. The choice needs only to cohere with the research purpose and strategy.

Sampling

Sampling is a method used when researchers cannot collect data from every entity in the research. It is used to select a limited-size subset of the population (i.e. sample). When the entire population is addressed rather than a sample, the data collection method is called a census.

Secondary data

Secondary data refer to the method used to collect data previously produced for other purposes, as opposed to primary data produced for the purpose of the ongoing research.

Observation

Observation is a method used to collect data on social actor behaviour and their environment. Collection is done by systematically observing and recording. If the observer seeks to understand the internal meaning of social actor actions, the method is called participant observation. On the other hand, if the research emphasises actions and event frequency, the method is called structured observation.

Four variants of participant observation can be identified. They relate to researcher involvement with (or detachment from) the phenomenon under study, and whether observations are made overtly or covertly.[50] Accordingly, the researcher can be a complete participant (i.e. involved and observing covertly), a participant-as-observer (i.e. involved and observing overtly), an observer-as-participant (i.e. distant and observing overtly), or a complete observer (i.e. distant and observing covertly).

To avoid any confusion that might arise where there is overlap between roles, an alternative typology is proposed for business research.[51] The researcher can observe: i) as employee (seeking complete immersion, and the research identity can either be revealed or concealed); ii) as per the explicit role (researcher's regular presence negotiated over a period of time, and research identity is revealed); iii) through interrupted involvement (previous presence or sporadic presence over time and revealed identity); iv) through observation alone (distant research and revealed identity); or v) through semi-concealed research (regular presence negotiated over time, revealed identity but concealed focus and objectives).

When the research emphasis is on the observer's connectedness to the studied field (i.e. observer understanding, interpretation, experience, stories, reactions, interactions with informants) rather than on the field itself, observation refers more to auto-ethnography.[52] Auto-ethnography or self-ethnography is sometimes defined as 'insider' ethnography, as opposed to outsider. It refers to a situation where the researcher is a member of the observed group or organisation.[53]

Interview

An interview refers to the purposeful question-answer exchange a researcher conducts to collect data from social actors (also called interviewees or respondents). Depending on the research purpose, exchanges can vary from highly structured to unstructured. A host of combinations fall between these two extremes. This diversity is represented by the following typology: structured interviews, semi-structured interviews and unstructured interviews (or in-depth interviews).

Unstructured interviews are associated with qualitative data collection, whilst structured interviews are associated with quantitative (or quantifiable) data. The latter are conducted on the basis of questionnaires that are administered by the researcher (interviewer-administered).

Structured interviews relate to a data collection method called a questionnaire. The questionnaire collects data by asking all respondents to answer the same set of predetermined questions submitted in the same order. Because of this 'standardisation', questionnaires lend themselves to quantitative (or quantifiable) data collection from large samples. They can be self-completed or interviewer-completed.[54]

5.3 Insights into methodological options in evaluation research

Evaluation research relies mainly on social science research methods and methodologies. Debate has raged among evaluation researchers about the relative merits of the two classical philosophical postures and approaches to adopt, positivist-deductive and interpretivist-inductive.[55] The former is preferred when the researcher determines an *a priori* set of outcomes to measure before collecting data over the evaluand (i.e. subject for evaluation).[56] The latter is used when the researcher considers that evaluation requires a clear understanding of the evaluand's outcomes, context and social actor interactions.

These two separate postures entail two distinct methodological choices in evaluation research. Quantitative evaluators make use of highly structured and standardised data collection methods (e.g. questionnaires and structured interviews). Qualitative evaluators employ non-standardised and less-structured data collection methods (e.g. in-depth interviews and observation).

5.3.1 Refuting the dichotomy in methodological choice

The above dichotomy in dealing with practical evaluation issues has limitations. A growing consensus around the notion of selecting the method that best suits the problem at hand has emerged over time. Many scholars urge evaluators to use suitable methods for their problems regardless of their assumptions. Cook et al. argue for the need "to use them together to satisfy the demands of evaluation research in the most efficacious manner possible".[57] Patton[58] draws attention to the nuances in evaluation issues and the need that evaluators develop a large quantitative and qualitative methods repertoire and use them according to the context. He considers that "the ideal in evaluation designs is methodological appropriateness, design flexibility, and situational responsiveness".[59] Methodological appropriateness does not necessarily mean using quantitative and qualitative methods together.

Patton also recognises that the pragmatic way of handling evaluation stems from a pragmatic philosophical stance. He highlights that an increasing number of researchers draws out the evaluation design from a pragmatic posture, then integrate multiple methods into a single evaluation research.

Using multiple methods, including mixing quantitative and qualitative methods, in the same evaluation study is essentially justified by the need to consider real-world conditions. There is a need to be creative and flexible in facing these conditions as one method's strengths can offset another's weaknesses.

Some observers argue that mixing methods in evaluation might jeopardise internal consistency. However, the majority of scholars consider that the human mind is sophisticated enough to mix deductive and inductive approaches and to manipulate quantitative and qualitative data in the same study.[60] To illustrate this, Patton offers the example of an evaluation study that begins with an inductive approach where the evaluator remains open to whatever comes out from the collected data. Then, on the basis of the data's revealed patterns, the evaluator adopts, for verification purposes, a focused deductive approach to collect and analyse further data.[61] He cites also the use of questionnaires within which open questions are asked.

5.3.2 Mixing summative, formative and knowledge-generating evaluations

Evaluations have essentially two discernible purposes: judgment or improvement. Evaluations are judgment-oriented or summative when they aim to "simply assess a program's goal attainment, making an overall judgment about merit or worth… [They] measure outcomes and impacts, and the causal linkages between program activities and outcomes that constitute a program model or theory".[62]

They are improvement-oriented or formative when the emphasis is on improving "programs by getting participant feedback and identifying strengths and weaknesses … [They] examine implementation, program processes, and program adaptations to changing clients or conditions".[63] In practice, both types are complementary, as formative evaluation can be undertaken to ultimately conduct summative evaluation.

Unlike summative evaluation in which the emphasis is on quantitative designs, formative evaluation (including other evaluations that share the general purpose of improvement and can be gathered under its umbrella) lends itself to qualitative designs.[64] Within the continuum of evaluation types where summative and formative evaluations are situated at opposite ends,[65] a host of in-between mixed method designs can be envisaged. They are defined according to the evaluation's conditions and the evaluator's skill, creativity and preferences.

Moreover, an open approach towards a variety of methods is further justified by the growth of the evaluation realm. This latter can no longer be confined to the summative-formative typology.[66] Patton[67] points out that instrumental use of outcomes or results in both summative and formative approaches prevents the conceptual use of findings. It limits thinking about issues, options and policy alternatives. For this reason, a trend towards knowledge-generating evaluations might be of import as "the knowledge generated can be as specific as clarifying a program's model, testing theory, distinguishing types of interventions, figuring out how to measure outcomes, generating lessons learned, and/or elaborating policy options".[68]

The influence of evaluator skills and preferences in designing an inquiry is portrayed through the concept known as "The Law of Instrument". Kaplan[69] formulates it as follows: "Give a small boy a hammer, and he will find that everything he encounters needs pounding".[70] Patton also addresses this phenomenon and terms it methodological prejudice.[71] He argues that evaluators make use of methods that are in line with their methodological background (previous training and experience in methods use) rather than exploring methods more appropriate to the encountered situation. Further empirical studies reveal that some evaluator characteristics, such as status (e.g. relationship to the evaluand), experience, theoretical orientation and educational level influence methodological choices. [72]

5.3.3 The appropriate evaluation for developing countries

In light of the above, the key term in evaluation may be said to be openness (to all methodological choices). This guiding principle should lead to a more question-centred rather than methods-driven evaluation. It must also be reconciled with the conditions under which the evaluation research is undertaken. In developing countries, conditions (e.g. economic, political, legal, and cultural) are different, and often more severe, compared to developed countries.

Bamberger et al.[73] assert that the trend in evaluation research addressing issues in developing countries is towards holistic evaluation. It gathers summative and formative aspects in a single study. They argue that this summative-formative duality can best be addressed by using mixed method design. They argue that neither quantitative nor qualitative design alone can capture the evaluand's environmental complexity.

In developing countries, the nature of the research question often ranges from operational to policy level. Accordingly, multi-level analysis (or evaluation) is an issue that needs addressing by evaluation researchers in these countries. Mixed method design is appropriate for multi-level evaluation, as each level requires specific (and different) methods to be evaluated.[74]

Evaluands in developing countries (e.g. projects, programmes) have tangible outcomes that can be measured (often quantitatively); they also have non-tangible outcomes (or impacts) that are difficult to capture without making use of both qualitative and quantitative instruments. This is why a mixed design is valuable, as it can overcome the inherent weaknesses of both quantitative and qualitative approaches.

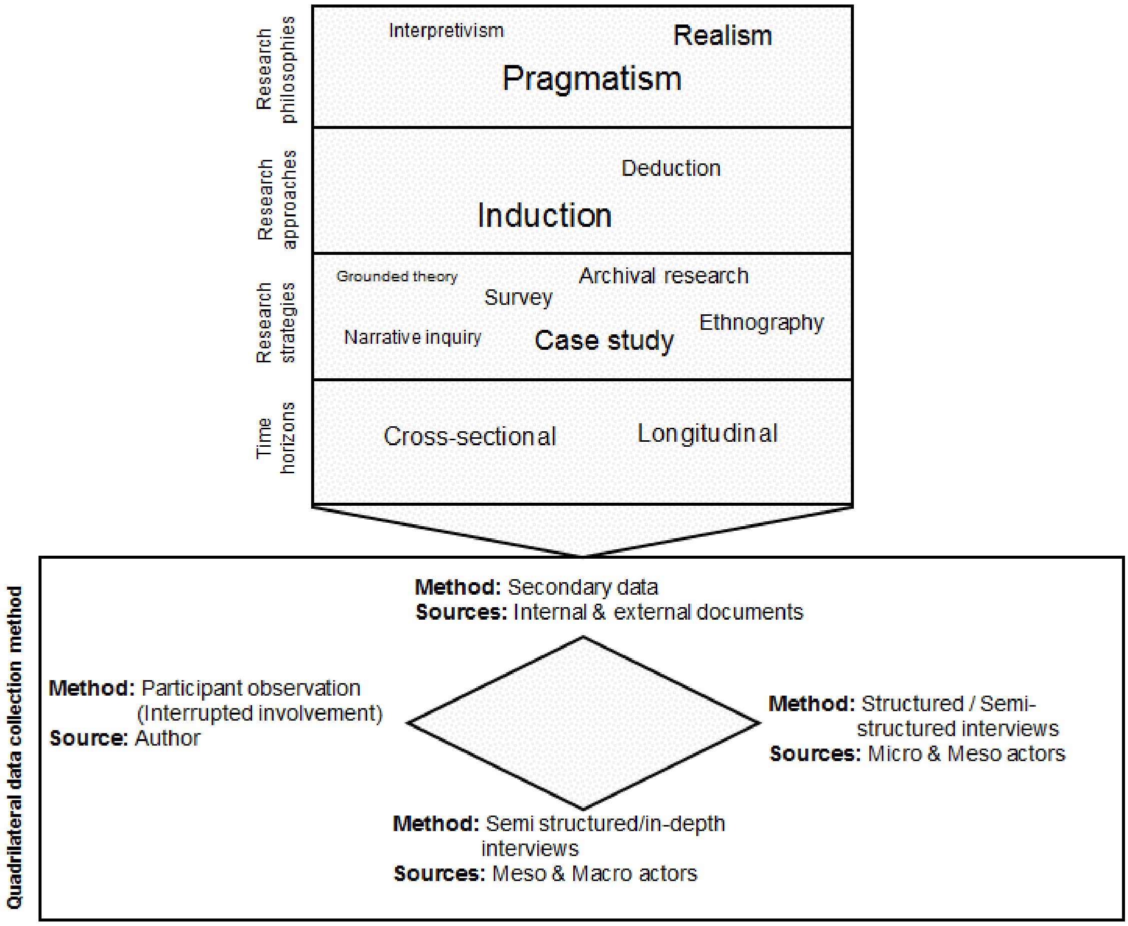
On the other hand, due to multiple constraints (e.g. deadlines, budget, data access), evaluation researchers tend to spend the available field-work time collecting data (often qualitatively) from stakeholders (or participants) directly involved with the evaluand (e.g. project, programme). These stakeholders tend to give positive feedback on the evaluand as they feel a part of it. Overcoming this positive bias is possible by using mixed methods – by identifying comparable non-participants and collecting data from them.[75]

5.4 Research design

Given the conditions under which the present study has been conducted, the mixed method design was deemed the most appropriate for its purposes. In order to demonstrate explicitly the consistency of the chosen design with the research purpose, Figure 5-3 illustrates the hierarchy of philosophical considerations and methodological choices underlying the adoption of the mixed design.

The upper part of Figure 5-3 illustrates the design formulation process through successive combinations of philosophies, approaches, strategies and time horizons. The process results in a combination of mutually supportive data collection techniques (quadrilateral data collection methods) illustrated in Figure 5-3's lower part. Various font sizes are used at each level (of the Figure's upper-part) to indicate degree of prevalence during the design formulation stage. For example, in the first layer, pragmatism prevails as the research philosophy, combined with elements of realism and then interpretivism.

Figure 5-3: Choices underpinning mixed method design



Source: Author

The present study is influenced by fundamental assumptions. The author's ontological position proceeds from a combination of subjective and objective lenses in perceiving the nature of reality. Epistemologically, the author considers that knowledge produced in the present research should reflect the human and social dimension. He also recognises that the research is value-laden, as he has been part of the studied phenomenon (satellite capability-building in Algeria) for approximately the last sixteen years.

The prevailing philosophical position that addresses this anti-dualistic[76] stance is pragmatism combined with elements of realism and interpretivism. Thus, pragmatism is adopted, as this research is question-centred. Pragmatism provides the flexibility of switching between philosophical and methodological options and combining multiple points of view in order to produce practically meaningful knowledge. This is one of the main objectives of the present research. Pragmatism is also adopted because of its major contribution to evaluation (particularly in developing countries) and management research that deals with knowledge management.

Elements of realism or to be precise critical realism are incorporated. Critical realism mainly recognises the value of multi-level studies in capturing different levels of perception. This accords with the levels of analysis adopted in the present research (micro, meso, and macro).

With regard to the research approach, a combination of inductive and deductive approaches is adopted. Inductive reasoning is predominant because of the limited theoretical knowledge available on the subject (i.e. satellite capability-building in developing countries). It is also adopted because the study does not seek any generalisation. On the other hand, the limited theoretical knowledge available is approached deductively in order to guide data collection.

The present study is at the same time exploratory, descriptive, analytical and predictive. Exploratory, as it seeks to gain insight into the subject of satellite capability-building, poorly studied in developing countries and not at all in Algeria. It is also descriptive, as it aims empirically to feature and inform the satellite capability-building characteristics in Algeria. The study is analytical, because it aims to analyse evidence and provide explanations as to satellite capability-building performance. Finally, it is predictive, as it attempts to prefigure future outcomes and suggest recommendations.

Due to the diversity of research sub-topics, the present study is particularly well suited to a mixed method design. It combines quantitative and qualitative elements for purposes of breadth and depth of understanding and corroboration. This is reflected in the many combinations[77] of strategies (archival research, case studies, survey, ethnography and narrative inquiry), time horizons (cross-sectional and longitudinal), and data collection methods (interviews, secondary data and observation) that have been adopted.

5.4.1 Combination of data collection methods

As the main contribution to knowledge in the present research stems from its empirical aspect, data richness and accuracy are crucial. For this reason, a quadrilateral data acquisition method is adopted. It incorporates mutually reinforcing methods: secondary data, structured/semi-structured interviews, semi-structured/in-depth interviews, participant observation (i.e. researcher observes through interrupted involvement).

The quadrilateral model subsumes a mixture of quantitative and qualitative methods as illustrated in Figure 5-3. It also includes data that are collected from diverse sources.

The multiplicity of methods and sources refers to two types of triangulation: data triangulation (i.e. the use of various sources in the same study) and methodological triangulation (i.e. the use of diverse methods in the same study).[78] In addition, theory triangulation[79] is used as a third triangulation type in this study. It relates to the use of diverse theoretical perspectives emanating from various bodies of knowledge (technological learning, technological capability-building, and technology transfer) in order to analyse data.

Staged fieldwork is conducted to gather data at three levels of analysis: individual and team level (the micro level or micro actors in Figure 5-3); organisational and inter-organisational level (the meso level or meso actors in Figure 5-3); and sectoral, national and international level (the macro level or macro actors in Figure 5-3). Data collection is centred on three collaborative small satellite projects (Table 5-2) that form the backbone of small satellite capability-building in Algeria. This is an instance of the multiple case study approach, where multiple sources of evidence are used.

Table 5-2: Algeria's collaborative small satellite projects

Satellite systems		Project title	Algerian part	Foreign part	Start date of the project
Alsat-1		Alsat-1 programme. Realisation of an EO (Earth Observation) satellite with KHTT (Know-how Transfer &Training) programme.	CTS (Centre of Space Techniques)	SSTL (Surrey Satellite Technology Ltd)/UK	2000
Alsat-2	Alsat-2A	Alsat-2A. Realisation of an EO (Earth Observation) satellite with technology transfer programme.	ASAL (Algerian Space Agency)	Astrium/France	2005
	Alsat-2B	Alsat-2B. Realisation of an EO (Earth Observation) satellite with technology transfer programme.	ASAL (Algerian Space Agency)	Astrium/France	2012
Alsat-1B		Alsat-1B programme. Realisation of an EO (Earth Observation) satellite with technology transfer programme.	ASAL (Algerian Space Agency)	SSTL (Surrey Satellite Technology Ltd)/UK	2014

Source: Author

It is worth noting that data collection has focused more on endogenous and local factors than exogenous and international factors. There are two reasons for this focus. First, the literature review highlights the preeminent role of local effort in any endeavour to build local technological capability through technology transfer. Second, time and funding limitations did not permit extension of data collection to international factors.

Theoretical knowledge has guided the data collection process. It has guided the formulation of interviews and focused attention of the participant observer (author). The studied population comprises a hierarchy of individuals from organisations involved in satellite activity in Algeria (policy, management, R&D individuals, technical individuals, academics, and foreign company representatives). The population is segmented by management level (micro, meso, and macro).

The population is selected based on the author's discussions with several individuals within the Algerian space agency who are involved in satellite capability-building activities or have primary knowledge of the subject. The make-up of the population is also determined based on the author's own knowledge of the space sector in Algeria, as he worked in the space field in Algeria, easing access to data and individuals.

Secondary Data

The first step of data collection was to delve into key secondary sources related to the topic. These data are quantitative and qualitative and collected for exploratory, descriptive and explanatory purposes. They are also used to triangulate findings based on primary data collection methods employed in this study. The author is tri-lingual (Arabic, French and English), and thus an extensive review of Algerian-related material was conducted and supplemented by international and sectoral reports.

A variety of sources was used to capture these data. This includes relevant research and seminar papers, annual reports, statistical abstracts, specialised magazines and journals, space conference proceedings, international reports on outer space activities (e.g. COPUOS[2] Reports, African space activities reports), commercial sources, ASAL's (Algerian space agency) publications, websites. In addition, governmental resources were exploited, such as documents relating to national development plans, science, technology and industrial policies.

[2] United Nations Committee on the Peaceful Uses of Outer Space - UNCOPUOS

As a member of the space community in Algeria, the author was granted access to the space organisation's records, which contributed a sizeable part of the secondary data collected. These records include internal documentation on the National Space Programme, elements from satellite procurement contracts, agreements, accords and MoUs on space technology, meeting minutes, blueprints, and project work packages.

The principal online resources used are listed in Table 5-3. The analysis of some online publications of the Algerian Space Agency required the use of certain functionality (e.g. word frequency) of the software NVivo 11 Pro.

Table 5-3: Online resources used in the study

Organisations	Websites
Algerian Space Agency	http://www.asal.dz/
Surrey Satellite technology	http://www.sstl.co.uk/
Airbus Defence and Space	https://airbusdefenceandspace.com
Centre National des Etudes Spatiales-CNES Satellite Platform : Myriade	https://myriade.cnes.fr/en/MYRIADE/index.htm
Korea Aerospace Research Institute	https://www.kari.re.kr
Indian Space Research Organisation	http://isro.gov.in
United Nations Committee on the Peaceful Uses of Outer Space – UNCOPUOS	http://www.unoosa.org/oosa/COPUOS/copuos.html
Algerian Prime Minister	http://www.premier-ministre.gov.dz
Algerian Ministry of Industry	http://www.industrie.gov.dz
Algerian Ministry of Higher Education and Scientific Research	https://www.mesrs.dz
World Bank, Doing Business	http://www.worldbank.org , http://www.doingbusiness.org
International Monetary Fund	http://www.imf.org
World Economic Forum	https://www.weforum.org
International Telecommunication Union	http://www.itu.int
United Nations Development Programme	http://www.undp.org
Organisation for Economic Co-operation and Development	http://www.oecd.org
Euroconsult, Engineering consulting	http://www.euroconsult-ec.com

Source: Author

Structured and semi-structured interviews at micro level

To collect data required for the evaluation of satellite capability-building at micro level (individuals and teams), two sets of mixed, structured, and semi-structured, interviews were employed. The first set (Appendices 1-a and 1-b) was addressed to every member of ASAL's satellite project teams. The population interviewed is listed in Table 5-4. The list of participants is in Appendix 1-c.

Table 5-4: Number of members interviewed against satellite projects

Satellite project	Team size	Number of interviewees	Location
Alsat-1	11	7	CDS-Oran (Algeria)
Alsat-2 (2A & 2B)	23	11	CDS-Oran and ASAL-Algiers (Algeria)
Alsat-1B	18	17	CDS-Oran (Algeria)
Total	52	35	

Source: Author

The second set (Appendices 1-d and 1-e) was addressed to ASAL's satellite project managers. The population interviewed is listed in Table 5-5.

Table 5-5: Satellite project managers interviewed

Satellite project	Name	Location	Current title/position
Alsat-1	Mr. Mohamed Bekhti	CDS – Oran (Algeria)	Head, Research Department on Space Instruments / CDS (formerly project manager Alsat-1)
Alsat-2	Mr. Abdelouahab Chikouche	ASAL-Algiers (Algeria)	Director of Programmes/ASAL (formerly project manager Alsat-2A)
Alsat-1B	Mr. Ayhane Benbouzid	CDS-Oran (Algeria)	Project manager Alsat-1B

Source: Author

Focused interviews containing a mixture of structured and semi-structured questions were employed for both populations. The structured questions were used to identify general patterns at micro level, apropos of the descriptive aspect to the study. The semi-structured questions are used to collect data on both the context, apropos of the exploratory aspect to the study, and on the relationships between variables revealed by the structured questions and prior theoretical knowledge available, apropos of the explanatory aspect.

The questions were organised in sections. The latter cover themes that emerged from the theoretical knowledge developed in chapters 2 and 3 and were synthesised through the analytical framework presented in chapter 4. In the second set of interviews, addressed to satellite project managers, themes related to team management and group work were emphasised.

Structured and semi-structured interviews at meso level

Three sets of 'mixed' – structured and semi-structured – interviews were employed to collect data at meso level. The first set (Appendices 2-a and 2-b) was addressed to representatives from ASAL's entities involved in satellite capability-building. Questions were selected from the list in Appendices 2-a and 2-b according to participant positions. The population interviewed is listed in Table 5-6.

Table 5-6: Interviewees from ASAL's entities

Name	Position	Organisation and location
Mr. Tahar Iftene	Director of Research & Training	ASAL – Algiers (Algeria)
Mr. Fethi Benhamouda	Director of Studies, in charge of scientific and technological watch	ASAL – Algiers (Algeria)
Mr. Djawed Benachir	Director of Space Applications	ASAL – Algiers (Algeria)
Mr. Abdelouahab Chikouche	Director of space programmes and industry development	ASAL – Algiers (Algeria)
Mr. Madani Arizou	Director, Centre of Space Techniques (CTS)	CTS – Arzew (Algeria)
Mr. Djamal Djebouri	Director, Centre of Satellite Development (CDS)	CDS – Oran (Algeria)
Mr. Ali Hassani backed by his collaborator Mrs R. Salah	Director, Centre of Space Applications (CAS)	CAS – Algiers (Algeria)

Source: Author

The second set (Appendices 2-c, 2-d, 2-e and 2-f) was addressed to representatives from ASAL's local partners involved in satellite capability-building. Questions were selected from the list in Appendices 2-c, 2-d, 2-e and 2-f according to participant positions. The population interviewed is listed in Table 5-7.

Table 5-7: Interviewees from ASAL's local partners

Name	Position	Organisation and location
Mr. Mostefa Rahli	Coordinator of Doctoral School of Technology and Space Applications (EDTAS). This school is a joint platform between five Universities: Algiers, Oran, Constantine, Setif, Tlemcen.	University of Oran (USTO) – Oran (Algeria)
Mr. Mohamed Bencib	Coordinator of relations with ASAL, representative of Aircraft construction company –ECA	ECA - Tafraoui (Algeria)

Source: Author

The third set (Appendices 2-g and 2-h) was addressed to representatives from ASAL's foreign satellite suppliers (contractors). The population interviewed is listed in Table 5-8.

Table 5-8: Interviewees from ASAL's satellite foreign suppliers (contractors)

Name	Position	Organisation and location
Mr. Andrew Cawthorne	Director of Earth Observation	Surrey Satellite Technology SSTL
Mr. Michel Siguier backed by Mr. Laurent Frech (in charge of relations with Algeria/Dpt of Marketing)	Alsat-2 Project manager	Airbus Defence and Space

Source: Author

The three sets of 'mixed' – structured and semi-structured – interviews employed at meso level were devised to collect data on organisational and inter-organisational aspects. The questions were aimed towards collecting data on connections between individual/group considerations and organisation/inter-organisation considerations.

The two sets of interviews addressed, respectively, to representatives from ASAL's entities and ASAL's local partners are organised according to thematic sections. These sections reflect the theoretical knowledge synthesised through the analytical framework presented in chapter 4. Interviews addressed to ASAL's local partners emphasise their activities as partners of the Algerian Space Agency.

The third set of interviews addressed to ASAL's foreign satellite suppliers (contractors) essentially deals with factors which are at the interface between the foreign supplier and the Algerian Space Agency (i.e. only one theme which is technology transfer-related).

Semi-structured/in-depth interviews at meso and macro levels

Semi-structured and in-depth interviews were held at both meso (i.e. organisation and inter-organisation) and macro (i.e. sectoral, national and international) levels. Questions were addressed to representatives from ASAL's entities (Appendices 2-a and 2-b), ASAL's local partners (Appendices 2-c, 2-d, 2-e and 2-f), and ASAL's top management (Appendices 2-i and 2-j). The population interviewed is listed in Tables 5-6 and 5-7 (for ASAL's entities and local partners) and Table 5-9 (for ASAL's top management).

Table 5-9: Interviewees from ASAL's top-management

Name	Position	Organisation and location
Mr. Omar Farouk Zerhouni	Chairman of the Board, Algerian Space Agency - ASAL	ASAL – Algiers (Algeria)
Mr. Azzeddine Oussedik	Director General, Algerian Space Agency - ASAL	ASAL – Algiers (Algeria)

Source: Author

Interviews at these levels were devised to collect data on sectoral, national and international aspects. A number of questions were aimed towards collecting data on connections between organisational considerations, on the one hand, and sectoral, national, and international considerations, on the other. Some open-ended questions were included in order to allow interviewees to talk freely about aspects of the satellite capability-building process within the national and international context. Open-ended questions were also used to gain insight into the beliefs of participants, particularly decision-makers, and their intentions regarding the direction the satellite capability-building process should take. This is apropos of the predictive aspect to the present study.

In all interviews (structured, semi-structured, and in-depth), the Arabic language was naturally used in discussion (except for interviews with foreign companies). However, because of the potential confusion that may arise from the translated technical satellite-related terminology, interviews were administered in French and English, as interviewees use one or both of these languages in their everyday professional activities. Questions were checked for translational accuracy during the interviews.

Questions at micro level were pilot-tested by two ASAL members of the satellite ground segment project with regard to the first set of interviews, and by a former project manager with regard to the second set of interviews. A sample of questions at meso and macro level was pilot-tested by the former director of international cooperation of the Algerian space agency. Questions were amended based on feedback from the pilot study. Amendments mainly had to do with the fact that the author might be perceived by participants (at lower levels, micro level) as a non-independent researcher because he is part of the space community in Algeria. Questions about relationships with managers, management commitment, and the decision-making process had to be de-sensitised.

Questions were updated and sent to interviewees well before the interviews. It was clearly stated that questions would be self-administered in the initial stage, and then interviewer-administered. Providing questions in advance of the interview session was thought to be a way of promoting validity and reliability, by allowing the interviewee to think thoroughly about the questions and assemble any supporting information or documentation for his/her response.[80] In the second stage, questions were interviewer-administered and reviewed during the face-to-face encounter to ensure proper understanding and to achieve a higher response rate. Later, during the data analysis stage, follow-up telephone conversations were conducted with some interviewees for clarification.

Interviews lasted from about one hour and a half to three hours. Interviews with members of satellite projects took the most time, as there was a need to develop trust. The issue of trust was implicitly encountered with Algerian participants. Amongst them, three conversations only were audio-recorded because the majority of participants did not give consent. It should be underlined that the present study is the first of its kind involving the space community in Algeria, and participants showed discomfort, as they had never experienced audio-recorded interviews before. This situation might reflect the secretive culture and lack of research culture within ASAL. Interviews with foreign company representatives were administered through Skype and recorded.

Interview translation (into English) and transcription was carried out using the "just the gist" mode of transcription. Gibbs[81] recommends this approach in evaluation research. "Just the gist" was also used to save time. Quantitative data were stored and analysed using MS Excel.

To sum up, interviews were conducted through three fieldwork campaigns: 19 face-to-face interviews during the first campaign (April and May 2016); 27 face-to-face interviews during the second campaign (July and August 2016); and 02 internet-mediated interviews during the third campaign (April 2017). The final pair of interviews, with foreign company representatives, were conducted later. The author sought to allow time for identifying the right persons to interview – by retrospection as to the complementary or other data that was lacking.

In addition, several follow-up interviews (via telephone or internet-mediated) were conducted; they are spread over approximately 10 months (from September 2016 to May 2017).

The original aim was to conduct 65 interviews, representing the whole population involved in small satellite projects (i.e. a census). However, five of the targeted interviewees left the organisation before the study and attempts to contact them were unsuccessful. Furthermore ten of the targeted interviewees were unavailable, as they were fully occupied with other tasks (e.g. Alsat-1B and Alsat-2B launch campaigns in India, commissioning satellites after launch). Two potential interviewees did not reply or declined the invitation to participate in the study. The participation rate for this study was thus 73.84%.

Interviews were conducted according to three levels of analysis: micro, meso, and macro. The targeted number of interviews at micro level was 52. However, 35 interviews were conducted, which corresponds to 67.30%. At this level, it was noticed that during the later interviews no new or relevant information was provided, which could be taken as an indication that the data gathering had attained saturation.

The targeted number of interviews at meso and macro levels was 13, corresponding to a 100% response rate.

The fieldwork approach also allowed collection of relevant secondary resources and internal documentation.

Participant observation (interrupted involvement)

Participant observation fits in well with this research, as the author has spent the past 16 years working in the space field in Algeria, at both technical and managerial level. The author was among those representatives of the Algerian Ministry of Defence most closely involved with the Algerian space agency's activities. The author also has first-hand experience of space policy formulation in Algeria. The close relationship the author enjoys with the Algerian space agency (at both management and operational levels) facilitated data collection through observation.

Accordingly, the present researcher's role has been a mixture of participant-as-observer (i.e. involved in space activity and observing overtly) and observer-as-participant (i.e. distant from space activity and observing overtly).[82] The role overlap corresponds to interrupted involvement (i.e. previous or sporadic presence over time and revealed identity).[83]

The author's participatory observation generated data consisting of primary and secondary observations as well as experiential data. Primary observation data relate mainly to proceedings in the three Alsat-1B meetings held at Surrey Space Centre/UK between ASAL and the Alsat-1B satellite supplier (SSTL) in November 2014, November 2015, and July 2017.

Secondary observation data relate to a number of informal conversations conducted in the author's presence. In general, conversations were held when the author visited ASAL, CDS and ECA (i.e. ASAL's local partner) facilities and had discussions with staff. Informal interviews were used to clarify observations. For instance, some of the most valuable data collected through secondary observation comes from informal interviews with: i) staff in charge of IT services and documentation management at CDS about memorising experience through a shared on-line database; ii) staff from ASAL's HQ about small satellite technology in the future space programme; and iii) personnel from ECA about communication difficulties with ASAL.

Experiential data relate to perceptions formed by the author in the process of observation. For instance, a number of instances were recorded where Alsat-1 project members expressed a wistful sense of unfinished business, regret, and even bitterness.

5.4.2 Ethical considerations

Ethics refers to "norms and standards of behaviour that guide moral choices about our behaviour and our relationships with others".[84] In the context of research, it refers to the appropriateness of researcher conduct when dealing with the research subject.[85] Discussion about ethical considerations revolves around key principles.[86] The first is that research which harms or does not respect the dignity of participants is regarded as unacceptable. The second is to protect the integrity of the research community by clarifying the nature and aim of the research and declaring any aspects that can lead to conflicts of interest (e.g. affiliations, funding sources). The third is to get the informed consent of the participant, protect his privacy and anonymity, and ensure the confidentiality of the data collected. The final principle relates to the moral integrity of the researcher, being honest, transparent when communicating, and avoiding misleading claims or false reporting.

It is important to mention that the present research is championed by the chairman of the board of the Algerian space agency. Based on a support letter from the researcher's supervisor (Appendix 3-a), the chairman of the board formerly requested the Director General of ASAL and his team to assist the researcher and provide access to data.

The purpose and context of this investigation were explained to participants ahead of time (Appendix 3-b). The author explained that participation is voluntary and participants are free to withdraw from the research at any time, without having to give reasons and without further consequences. The author avoided questions that might put participants under pressure or create stress or discomfort. The author assured participants that their privacy and anonymity would be protected. Participants were assured that they could withdraw their data from the study at any time. The author also assured participants that data collected would be treated as confidential, stored in a safe place that only the researcher had access to. No participants would be named in any publication and no information that identifies participants would be published without consent. To preserve anonymity, the participants are identified through codes (ID-1, ID-2, etc.). Finally, prior to conducting interviews, participants were asked to give their formal consent (Appendices 3-c and 3-d). It is important to mention that this study gained Cranfield University[3] ethical approval prior to its commencement.

[3] Through the Cranfield University Research Ethics System (CURES).

5.4.3 Research quality

Research quality is usually examined through its reliability and validity.[87] Reliability refers to whether “data collection techniques and analytical procedures would produce consistent findings”.[88] Reliability is not sufficient to ensure research quality. The validity of the findings should be examined by determining whether they are really what they pretend to be.[89] As explained above (section 5.4), consistency between the research design and the research purpose has been explicitly demonstrated. The process led to the adoption of a methodological ‘quadrangulation’ (Figure 5-3). In addition, a triangulation of sources was used. Participants at several levels of analysis were involved (i.e. micro, meso, and macro levels). Secondary and internal documentation were also used.

The following factors further fostered research quality: i) The number of interviews (and response rate) and the way they were conducted; ii) The diverse theoretical perspectives (i.e. theory triangulation) used in analysing data; iii) The researcher’s dual role, as an insider within the space organisation in Algeria and as a ‘detached’ outsider pursuing a full-time PhD in the UK; iv) The duality in the researcher’s professional and academic backgrounds (engineering and management) which makes it easier to collect, manipulate and analyse data.

Finally, it is important to recognise that the present research was conducted under particular settings. It is both technology-specific and country-specific. Its findings are unique to small satellite technology within the Algerian context. They are not generalisable; however, they can offer useful insights into understanding the process of complex technology transfer into developing countries.

References and Notes

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[1] Management of Technology is defined as "linking engineering, science, and management disciplines to plan, develop, and implement technological capabilities to shape and accomplish the strategic and operational objectives of an organization". The U.S. National Research Council definition, 1987. http://www.referenceforbusiness.com/management/Str-Ti/Technology-Management.html and https://binnur.wordpress.com/2013/02/11/technology-management-intro/ (Accessed on 05 April 2015).

[2] Management evaluation is defined as "Rigorous analysis of completed or ongoing activities that determine or support management accountability, effectiveness, and efficiency". http://www.businessdictionary.com/definition/evaluation.html (Accessed on 05 April 2015).

[3] Technology Evaluation can be defined as "a set of principles, methods and techniques/tools for effective assessing the potential value of a technology and its contribution to company's competitiveness and profitability". Bakouros, Y., 2000. Technology Evaluation. Report produced for the EC-European Community funded project. INNOREGIO: dissemination of innovation and knowledge management techniques, p.3. http://www.adi.pt/docs/innoregio_techn_evaluation.pdf (Accessed on 05 April 2015).

[4] Easterby-Smith, M., Thorpe, R., Jackson, P., 2012. Management research. Forth Edition, SAGE Publications Ltd, pp.12-13.

Saunders, M., Lewis, P., Thornhill, A., 2012. Research methods for business students. 6th Edition, Pearson Education Limited, p.8.

[5] Ibid.

[6] Evaluation research is considered as an action oriented social research.

Clark, A., Dawson, R., 1999. Evaluation Research, An Introduction to Principles, Methods and Practice. SAGE Publications Ltd, p.vi.

[7] Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., Trow, M., 1994. The New Production of Knowledge: The Dynamics of Science and Research in contemporary societies. SAGE Publications Ltd, pp.1-45.

[8] Ibid.

[9] Huff, A.S., 2000. 1999 Presidential Address: Changes in organizational knowledge production. Academy of Management review 25, 288-293.

[10] Such as:

Easterby-Smith et al. (2012), op. cit.

Saunders et al. (2012), op. cit.

Hodgkinson, G.P., Herriot, P., Anderson, N., 2001. Re-aligning the Stakeholders in Management Research- Lessons from Industrial, Work and Organizational Psychology. British Journal of Management 12, S41–S48.

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[11] Starkey, K., Madan, P., 2001. Bridging the Relevance Gap: Aligning Stakeholders in the Future of Management Research. British Journal of Management 12(S), S3-S26.

[12] Gummesson, E., 1991. Qualitative Methods in Management Research. SAGE Publications, pp.11-14, pp.135-174.

Hodgkinson et al. (2001), op. cit.

[13] The author of the present thesis has a multi-disciplinary educational background including engineering (Computer Science, Information System, Space Technologies), Law, Business and Management along with more than 13 years in the Space field in Algeria, involved in technical and managerial tasks.

[14] Shively, W.P., 2009. The Craft of Political Research. 7th Edition, Pearson Prentice Hall, p.4.

Clark & Dawson (1999), op. cit., pp.2-3.

Easterby-Smith et al. (2012), op. cit, pp.2-3.

Saunders et al. (2012), op. cit., pp.11-12.

[15] University of Cranfield Senate Regulations, Version 2.2, November 2014, point 61.2, as part of the requirements for conferment of a Doctoral degree.

[16] The word ‘local’ is borrowed from the following:

the concept of ‘local’ theory addressed by Gummesson when advocating the view that “local theory is perhaps the only type of theory that can be created in social science” and “the doubt and skepticism about the meaning of the concept of generalization in social science”, Gummesson (1991), pp.78-86.

Easterby-Smith et al. defined local knowledge as ”ideas and principles that are relevant to the setting of a particular organization or social setting, but which may not apply in other contexts”.

Easterby-Smith, M., Thorpe, R., Jackson, P.R., 2015. Management research. 5th Edition, SAGE Publications Ltd, p.337.

[17] Saunders et al. (2012), op. cit., p.127.

[18] Clark & Dawson (1999), op. cit., pp.35-41.

[19] Saunders et al. (2012), op. cit., pp.126-207.

[20] Easterby-Smith et al. (2012), op. cit, pp.16-74.

[21] Saunders et al. (2012), op. cit., pp.126-207.

[22] Easterby-Smith et al. (2012), op. cit, pp.16-74.

[23] Tashakkori, A., Teddlie, C., 2010. Sage Handbook of Mixed Methods in Social and Behavioural Research. SAGE Publications Ltd, p.16.

[24] Saunders et al. (2012), op. cit., pp.130-132.

[25] Bryman, A., Bell, E., 2007. Business research method. Second Edition, Oxford University Press, pp.16-21.

[26] Creswell, J.W., 1994. Research Design: Qualitative and Quantitative Approaches. SAGE Publications, pp.4-7.

[27] Collis, J., Hussey, R., 2014. Business research: a practical guide for undergraduate & postgraduate students. 4th Edition, Basingstoke, Hampshire : Palgrave Macmillan , pp.43-51

[28] Smith, J.K., 1983. Quantitative Versus Qualitative Research: An Attempt to Clarify the Issue. Educational Researcher, pp.6-13.

[29] Ibid.

[30] Saunders et al. (2012), op. cit., pp.130-137.

Easterby-Smith et al. (2015), op. cit., pp.57-64.

[31] Saunders et al. (2012), op. cit., pp.136-137.

[32] Collis & Hussey (2014), op. cit., pp.54-55.

[33] Watson, T.J., 2011. Ethnography, Reality, and Truth: The Vital Need for Studies of ‘How Things Work’ in Organizations and Management. Journal of Management Studies 48(1), 202–217.

[34] Ibid.

[35] Easterby-Smith et al. (2015), op. cit, p.61.

[36] http://www2.le.ac.uk/departments/gradschool/training/eresources/teaching/theories/kolb (Accessed on 12 May 2015)

[37] Onwuegbuzie, A.J., Leech, N.L., 2005.b. On Becoming a Pragmatic Researcher: The Importance of Combining Quantitative and Qualitative Research Methodologies. International Journal of Social Research Methodology 8(5), 375–387.

[38] Ketokivi, M., Mantere, S., 2010. Two Strategies for Inductive Reasoning in Organizational Research. Academy of Management Review 35(2), 315–333.

[39] Saunders et al. (2012), op. cit., pp.147-148.

[40] Van Maanen, J., Sørensen, J.B., Mitchell, T.R., 2007. The Interplay between Theory and Method. The Academy of Management Review 32(4), 1145-1154.

[41] Saunders et al. (2012), op. cit., p.161.

[42] Biesta, B., 2010. Pragmatism and the philosophical foundations of mixed methods research. In: Tashakkori & Teddlie (2010), op.cit., pp.95-117.

Maxwell, J.A., Mittapalli, K., 2010. Realism as stance for mixed methods research. In: Tashakkori & Teddlie (2010), op.cit., pp.145-167.

[43] Some variants of mixed methods are: fully or partially integrated mixed methods, single-phase, double-phase or multi-phase research design, sequential or concurrent mixed methods, sequential exploratory research design, concurrent mixed methods research, concurrent triangulation design, embedded mixed methods research, concurrent embedded design. Saunders et al. (2012), op. cit., pp.166-169.

[44] Collis & Hussey (2014), op. cit., pp.05-06.

[45] Ibid.

[46] Ethnography was developed as discipline during 1700s-1900s and appeared as research strategy from 1920s.

[47] Kurt Lewin introduced Action research strategy in 1946.

[48] Barney Glaser and Anselm Strauss introduced Grounded theory strategy in 1967.

[49] Example: single-case design, multiple-case design, and both of them can be either holistic (when based on single unit of analysis) or embedded (when based on multiple units of analysis). Yin, R.K., 2003. Case Study Research Designs and Methods. 3rd Edition, Sage Publications, pp.39-53.

[50] Gold, R., 1958. Roles in sociological field observations. Social Forces 36, 217-223. Second reference cited in Bryman & Bell (2007), op. cit., pp.454-458.

Saunders et al. (2012), op. cit., pp.343-345.

Guest, G., Namey, E.E., Mitchell, M.L., 2013. Collecting Qualitative Data - A Field Manual for Applied Research. SAGE Publications, Inc, pp.88-89.

[51] Easterby-Smith et al. (2012), op. cit, pp.144-148.

[52] Easterby-Smith et al. (2015), op. cit, p.168.

[53] Hayano, D.M., 1979. Auto-Ethnography: Paradigms, Problems, and Prospects. Human Organization 38(1), 99-104.

[54] Saunders et al. (2012), op. cit., pp.419-420.

[55] Clark & Dawson (1999), op. cit., pp.40-56.

[56] The evaluand is the entity being evaluated or the matter subject to evaluation, it can be "a program, product, organisation, intervention, or change effort".

Patton, M.Q., 2004. Evaluation Research. In Lewis-Beck, M.S., Bryman, A., Book, TFL.(Eds.), 2004. Encyclopedia of Social Science Research Methods. SAGE Publications, Inc, pp.338-342.

[57] Cook, T.D., Reichardt, C.S., 1979. Qualitative and quantitative methods in evaluation research. Sage Publications, p.27. Second reference in Clark & Dawson (1999), op. cit., p.62.

[58] Patton, M.Q., 2002. Qualitative Research & Evaluation Methods. SAGE Publications, pp.68-69

[59] Ibid., p.68.

[60] Ibid., pp.247-257.

[61] Ibid., p.253.

[62] Patton (2004), op. cit., p.338.

[63] Ibid.

[64] Patton (2002), op. cit., p.220.

[65] Herman, J.L., Morris, L.L., Fitz-Gibbon, C.T., 1987. Evaluators handbook. Sage Publications, p.26. Second reference in Clark & Dawson (1999), op. cit., pp.7-8.

[66] Patton, M.Q., 1996. A World Larger than Formative and Summative. Evaluation Practice 17(2), pp.131-144

[67] Patton (2004), op. cit., pp.338-342.

[68] Ibid., p.339.

[69] Kaplan, A., 1964. The conduct of inquiry. San Francisco Chandler Press.

[70] Ibid., p.28.

[71] Patton, M.Q., 1987. Evaluation's political inherency: Practical implications for design and use. In Palumbo, D.J., (Ed), 1987. The politics of program evaluation. Sage, pp.100-145.

[72] Christie, C.A., 2003. What guides evaluation? A study of how evaluation practice maps onto evaluation theory. New Directions in Evaluation 97, 7-35.

Azzam, T., 2011. Evaluator Characteristics and Methodological Choice. American Journal of Evaluation 32(3), 376-391.

[73] Bamberger, M., Rao, V., Woolcock, M., 2010. Using mixed methods in monitoring and evaluation: Experience from International Development. In: Tashakkori & Teddlie (2010), op.cit., pp.613-641.

[74] Tashakkori, A., Teddlie, C., (Eds.). 2008. Foundation of mixed methods research: Integrating quantitative and qualitative approaches in social and behavioral sciences. SAGE Publications Ltd, p.156.

[75] Bamberger, M., 2009. Why Do Many International Development Evaluations Have a Positive Bias? Should We Worry? Evaluation Journal of Australasia 9(2), 39-49.

[76] The antidualistic stance is the tendency to regard everything as continuous. It is also linked to synechism as it underpins the synechistic view aiming to integrating numerous continua in research. Johnson, B., Gray, R., 2010. A history of philosophical and theoretical issues for mixed methods research. In: Tashakkori & Teddlie (2010), op.cit., pp.69-94.

[77] Combination is made possible at all levels as research philosophies and methodologies are thought of as belonging to the same philosophical and methodological continua, as opposed to the dichotomic perception. Niglas, K., 2010. The multidimensional model of research methodology – An integrated set of continua. In: Tashakkori & Teddlie (2010), op.cit., pp.215-236.

[78] Denzin identifies four basic types of triangulations, Data triangulation, Methodological triangulation, Theory triangulation, Investigator triangulation (the use of various researchers for the same study).

Denzin, N.K., 2009. The Research Act: A Theoretical Introduction to Sociological Methods. Published by Aldine transaction, pp.301-313.

[79] Ibid.

[80] Saunders et al. (2012), op. cit., pp.385-386.

[81] Gibbs, G.R., 2010. Type of transcription for qualitative research. https://www.youtube.com/watch?v=3cZQvDteFZI (Accessed on 28 March 2017)

[82] Gold (1958), op. cit., pp.217-223.

Guest et al. (2013), op. cit., pp.88-89.

[83] Easterby-Smith et al. (2012), op. cit, pp.144-148.

[84] Cooper, D.R., Schindler, P.S., 2008. Business Research Methods. 10th Edition. Boston, MA and Burr Ridge, IL: McGraw-Hill, p.34.

[85] Saunders et al. (2012), op. cit., p.226

[86] Easterby-Smith et al. (2015), op. cit, p.122.

[87] Ibid., p.103.

[88] Saunders et al. (2012), op. cit., p.192.

[89] Ibid., p.193.

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Chapter 6: Planning small satellite capability-building in the Algerian context

The analysis and findings concerning the evaluation of small satellite capability-building in Algeria are synthesised in the present and following chapter (chapters 6 & 7). The scope of the present chapter takes in mostly macro considerations, and the manner in which they cascade down to lower levels of aggregation (i.e. meso level). Algeria's technological context is reviewed. First, section 6.1 sets out key ideas salient to Algeria's developmental path over the last five decades. Then, section 6.2 identifies the major milestones of Algeria's technological capability development. It also analyses the related industrial, science, and technological policies adopted, highlighting elements of an emerging National Innovation System. Section 6.3 evaluates the elements that shape the satellite sectoral innovation system. It traces and evaluates the process of small satellite capability-building from an innovation system perspective. Finally, section 6.4 examines the planning process of small satellite capability-building in Algeria.

6.1 Key ideas for grasping Algeria's development context

Given the paucity of academic resources examining the relatively short path of Algeria's technological development, it is necessary to devote a part of this thesis to addressing this lacuna in the literature. The discussion begins with a description of three key ideas that scholars consider essential for understanding Algeria's development.

The first idea is 'historical', and has been clearly enunciated by Benbitour.[1] It refers to the situation in Algeria on the eve of the outbreak of the 1954 armed revolution against the French colonialists, which led to independence in 1962. Algeria's population had suffered under colonial repression that dated back more than a century, in spite of the actions of resistance movement (political and military); all efforts to overthrow the French regime seemed doomed to failure. Algerian pro-independence politicians and elites were divided, and engaged in a relentless ideological struggle for leadership. In the country's independence efforts, attempts to bring change through political action were suppressed by the French. In this atmosphere of misery, despair, and lack of leadership, a group of young Algerians, who came from political movements, organised and unified themselves, and triggered the liberation war in November 1954.

Faced with this powerful liberation movement, the elites had no choice but to line up behind this new young generation. The elites of that time had lost the initiative at a crucial moment in Algeria's history. Benbitour[2] qualifies this as a hard blow that still, today, has resonance in the marginalisation of elites in favour of the unity of action. This conflict prevented the fostering of proper critical thinking, delaying the adoption of development policies and strategies. Djeflat[3] argues that the need to overcome such distractions requires a new pact between political leaders and the knowledge elite.

The second idea underpinning Algeria's development is 'ideological'. It refers to the post-independence political and economic choices opted into by Algeria. Self-reliance, self-sufficiency and indigenisation are central to the national debate and perceived as objectives towards completion of independence.

The third idea is 'economic and managerial'. It refers to Algeria's confusion of industrialisation and development. This confusion is engendered by a number of Algerian politicians, and even economists, who believe that industrialisation necessarily leads to development (see chapter 2, sections 2.1 and 2.2). The view conceals the conditions, mainly managerial, necessary to turn an industrialisation process into one of development.[4]

Overall, the combination of the above three foundational ideas underpins Algeria's developmental path over the previous five decades.

6.2 Major milestones in Algeria's technological capability-building

Few studies[5] address technological capability development in Algeria, alongside related industrial, science, and technology policies. Generally, there is agreement that the capability-building process started in the late 1960s following a gradual maturation period that began in 1962, just after independence. The main characteristic of this post-independence period was the plethora of development barriers. The country lost hundreds of thousands of people out of its population during the Liberation War, mostly among the younger and the more productive. The country also had an illiteracy rate close to 90% and a schooling rate of somewhere around 20%.[6]

The colonial infrastructure (industrial plants, agricultural land, schools and administrative services) was left virtually without supervision because of the exodus of French settlers after the independence. The priority was to cater the urgent need of operating and developing the existing infrastructure, helping to lay the foundations of the new fledgling Algerian state. Algeria opted for the socialist political model, and this choice was influenced, *inter alia*, by the support given by the Eastern Bloc in Algeria's liberation war.

6.2.1 Unrealistic industrialisation strategy

By the end of the 1960s, industrialisation choices were made and confirmed. Unbridled industrialisation commenced. It was based on an import substitution strategy inspired by the theoretical model of De Bernis,[7] who promoted the idea of the 'industrialising industry', favouring heavy industry and its products (e.g. steel, petrochemicals). This would allow the establishment of equipment industries (e.g. trucks, machine tools), which would in turn stimulate small and medium enterprises, processing industries, consumption and services.

In this strategy, the spearhead of development was state-owned companies guided by centralised government planning. Four government plans allocated considerable resources to an investment programme from 1967 to 1984. Table 6-1 shows the evolution of investment by sector and particularly the increasing importance of the industrial sector. These plans were funded primarily by hydrocarbon income and external debt. In 1970, the external debt of Algeria was 0.5 billion US dollars, but by 1978, it reached 18 billion US dollars.[8] From 1974 to 1978, over 75% of investment came from the country's external debt.[9]

Table 6-1: Investment programmes and allocated resources

Plan		Investment (% of the GNP)	Sectors					
			industry (share of investment)		**Agriculture** (share of investment)		**other sectors** (share of investment)	
			billion Dinars	**%**	billion Dinars	**%**	billion Dinars	**%**
1967-1969		24.6	4.9	53.4	1.9	20.7	2.3	25.8
1970-1973		46.0	20.8	57.3	4.3	12.0	11.4	30.7
1974-1979	1974/77	55.0	8.9	7.3	74.1	61.1	38.2	31.6
	1978/79		/	/	/	/	/	/
1980-1984		60.0	/	/	/	/	/	/

Source: adapted from plan documents. Second reference in Lamiri, A., 2013.La décennie de la dernière chance : émergence ou déchéance de l'économie algérienne. Chihab Editions, p.62. And from Dahmani, A.M., 1985. L'Engineering dans la Maîtrise Industrielle et Technologique. Office des Publications Universitaires, Algiers. Second reference in Saad, M., Zawdie, G., 2005. From Technology Transfer to the Emergence of a Triple Helix Culture: The Experience of Algeria in Innovation and Technological Capability Development. Technology Analysis & Strategic Management 17(1), 89-103.

With regard to technology, Algeria's industrialisation rested on embodied advanced technology.[10] This was imported by the 15 state companies created to cover key strategic sectors or industries (e.g. petrochemical, steel, metallurgy engineering, electronics, building materials, electrical goods, food processing, mining and textiles).[11] The expectations were that linkages between these state-owned companies would permit upstream and downstream integration (i.e. inter-sectoral or inter-industry) of the whole economy. Additionally, each company would be the main component of an industrial cluster (i.e. sectoral) with forward and backward linkages (i.e. intra-sectoral or intra-industry).[12]

The technology transfer mechanism used in the beginning was 'turnkey contracts'. Technology was embodied and contracts were complex and highly integrated. Foreign companies completed all of the project phases until the facilities were commissioned. The Algerian counterpart then operated the system. Requirements for effectively operating and managing the system went beyond the basic operational training Algeria received as part of the package. Algerians had limited capabilities, finding technology complex and difficult to understand. Moreover, often technological choices were inappropriate to the local socio-economic conditions.[13]

Later, in order to bypass these problems, ‘product-in-hand contracts’ were used as the mechanism for technology transfer. Technology provider involvement went beyond commissioning. They were asked to provide assistance and training to ensure effective operations and management. This mechanism was obviously more effective in terms of production output, whether in terms of quality or quantity. However, the mechanism had its downsides, “it fails to give local managers the hands-on experience of project design and project implementation they would need to be able to move up on the learning curve”.[14] The reasons were that foreign contractors, in seeking to minimise exposure to risk, did not wish to completely hand over responsibility to local managers during the transitory period. In addition, the overseas management team resorted to experienced foreign sub-contractors rather than involving inexperienced local companies.[15] Therefore, both mechanisms, ‘turnkey contracts’ and ‘product-in-hand contracts’, turned out to be unsuccessful in enabling technology absorption at the local level.

In respect of scientific and technological policies, despite attempts to build a stronger nexus between such policies and development strategies, decision makers failed in reconciling them. They addressed market failures by creating institutions.[16] Two approaches were simultaneously adopted. The first was basic research, led by the Ministry of Higher Education and Scientific Research. The second was applied research, led by a scattered industrial sector represented through separate central administrations and state-owned companies.

However, the overall system came progressively to be slanted towards scientific and basic research rather than technological and applied research.[17] This was mainly the consequence of: i) the lack of leadership and coordination of the industrial sector, where inconsistencies, and even contradictions, emerged with regard to priorities; ii) a biased incentive system which did not foster indigenous technological production; and also iii) the lack of support for an incremental innovation dynamic and the unsuitability of the devised policies to such processes.[18]

Analysis of this period reveals that the average capacity utilisation rate of Algeria's industries was below 55%.[19] Economic growth was around 6.5%, and it was funded by approximately 45% of GDP.[20] Around the same time, South Korea had also invested in industrialisation; it had a capacity utilisation rate of over 90%, and it reached 7% growth by investing only 18% of its GDP.[21] The rest was funded by the positive cash flows of companies.[22] In Algeria, the 'industrial production/fixed capital stock' ratio fell by half between 1967 and 1978, and the 'industrial production/workforce' ratio dropped by 11% over the same period.[23] "During this period, to produce one additional dinar, 3.6 dinars had to be invested in other sectors",[24] with investments continuously bankrolled by foreign capital.[25]

The verdict on this first development experience in Algeria was disappointing. The expected inter- and intra-industry linkages never materialised. Industries that were supposed to diffuse technology locally and be engines of development had only a small ripple effect on other branches. The industrialisation programme failed to meet its promise, i.e. kick-start a process of wealth-creation. It was, rather, a process of wealth-destruction - at the opposite of the development spectrum.[26]

6.2.2 Reforms, and industrial base rationalisation

A new governing team in Algeria took office in the late 1970s, and questioned the foundations of the economic model chosen. This team halted the unbridled industrialisation process but did not formally challenge the 'socialist' model.[27] It conducted reforms qualified as 'reorientation', like all the socialist bloc states at that time. Central planning continued to be the main instrument of economic management. These reforms accorded greater importance to SMEs, improving managerial skills, increasing consumption, and organically restructuring large state-owned enterprises.[28] Between 1981 and 1985, economic growth was around 5% per year.[29] This was achieved, in part, by improving the capacity utilisation rate, which increased from 55% to 70%.[30] Debt levels remained the same as in 1978 (i.e. 18 billion US dollars) because the price of oil rose during this period, enabling the financing of investment and consumption plans without resorting to debt.[31]

After the 1986's oil price collapse, the reforms were interrupted. The economic and social situation deteriorated and led to the 1988 revolt that called for more social justice and political freedom. A new constitution was adopted; it enshrined the multi-party system and all principles that are the mainstay of modern democracies. A new governing team broke with the planned economy and adopted a market economy as the principal economic doctrine. However, the measures taken to effect the transition were not sufficient, as they were an attempt to build a market economy with inefficient state-owned companies, representing more than 80% of the non-hydrocarbon economy and more than 90% if the hydrocarbon sector is included.[32]

With regard to technological capability-building, the large, unmanageable state-owned companies were broken up into smaller companies, either vertically or horizontally, in the early 1980s. The aim was to enhance learning and improve performance.[33] Also, in an attempt to reconcile the needs of an appropriate technological and scientific environment with the government's strategy of balanced regional development, company head offices were installed in various regions, with new universities (if none already existed).[34] However, the results of university-industry linkages fell far short of expectations. 'Relationships' turned out to be central planning-dependent and bureaucratic.

Privatisation and SME development formed a significant part of the reform package of the 1980s. It strove to conform with a new competition-driven efficiency culture by enhancing learning and innovation. Incremental innovation activity was promoted (to improve product quality, enlarge product functionality, and secure ISO certification) supported by embryonic partnerships between industry and R&D institutions.[35]

6.2.3 Development continuity despite major difficulties

In the early 1990s, an acute political crisis manifested with the rise of political and later armed Islamism. Economic strategy was no longer a priority due to the security situation. All the while, the economic and social crisis deepened. Algeria was forced to negotiate with the IMF in 1994 to reschedule its public and private debt. It also negotiated a structural adjustment plan. The market liberalisation and removal of price controls imposed by the IMF had adverse effects on Algerian companies.[36] They were not prepared for global competition, and, while the IMF agreements enabled Algeria to become solvent, they worked against sustainable development.[37]

The decade 1990-2000 is considered by a large number of Algerian scholars, politicians and economists to have seen a break in the process of development.[38] However, other scholars take the view that there were signs of an emerging national innovation system, despite the crisis.[39] Privatisation continued, the importance accorded to SMEs rose, and steps towards learning enhancement and skill development were ramped up. The maturation of ideas led to the promulgation of the 1998 Law of Orientation and Programmes for the Development of Scientific Research and Technological Development.[40]

The 1998 law laid the foundations of a national innovation system, covering institutional aspects, regulatory frameworks, planning priorities, resource mobilisation (e.g. human, financial), and incentive schemes.[41] The Law declared 22 broad objectives, including 'the development and application of space techniques' (Article 3). The law introduced 19 National Research Programmes (PNRs), including a programme for space technologies and their applications (Article 10). These PNRs were launched in 1999 by the Ministry of Higher Education and Scientific Research and targeted more than 30 sectors. Sectoral and inter-sectoral commissions were installed for coordinating and orienting research activity.

6.2.4 Growth in financial resources, 'easy' choices and 'Dutch Disease'

In the late 1990s, the easing of the security crisis became noticeable and oil prices rose. Algeria could be financially self-sufficient once again. The government opted for an economic recovery strategy based on Keynesian-type government spending to stimulate growth and employment.[42] Three plans were successively adopted: i) the plan for economic recovery support (2001-2004); ii) a complementary plan for economic growth support (2004-2009); and iii) a complementary plan for growth support (2010-2014). The overall strategy was to develop and modernise the socio-economic infrastructure, in the hopes that the productive sector would receive a productivity boost and grow as a consequence.[43] Expenditure across these three plans was around 500 billion US dollars (equivalent to about 500,000 billion Algerian dinars).[44] The industrial sector, notably state-owned companies, benefited from significant resources, including over 2,000 billion dinars for industrial revival and 150 billion dinars in SME upgrading.[45]

In terms of results, despite the arguments put forward by the government in favour of the macroeconomic rebalancing enabled by these plans,[46] many scholars[47] wonder 'at what cost?' They questioned the results and their sustainability for the following reasons: i) the Keynesian-type remedy was not adapted to the Algerian situation;[48] and ii) micro-economic indicators showed signs of weakness (e.g. decreasing productivity, decreasing international competitiveness, insufficient numbers of companies created, low spending on R&D, a discouraging business environment, a low technological development index and a low Human Development Index).[49]

Overall, there is almost complete consensus among experts[50] that the transition process from a planned to a market economy, initiated 25 years ago, is not yet complete. Analyses show that over the last fifteen years Algeria has been a victim of the "Dutch Disease".[51] To stage a recovery, optimistic observers hold that Algeria still has room for manoeuvre in her effort to become a North African 'tiger' – by adjusting her policy and correcting for past mistakes.[52] However, pessimistic opinion holds that the 2008 financial crisis and the failure of extreme liberalism in developed countries could prolong the uncertainty around economic choices and the *status quo* in Algeria's administered economy.[53]

With regard to technological capability-building, international technological partnerships were sought in order to develop products for both domestic and international markets. Needs of the international technological partnerships in terms of engineering and R&D activities competed with indigenous engineering and R&D activities. The indigenous capacity of local companies was already rather limited.[54] Companies faced a shortage of skilled human resources, equipment, time, incentives, and institutional frameworks. As a consequence, foreign engineering and R&D activities have progressively eclipsed local activities.[55] Local R&D capacity substitution occurred by recourse to foreign capacities instead of tapping domestic sources of expertise, or at least complementing foreign capacity with local.[56] Consequently, less than 16% of the funds injected into the national research system were absorbed.[57]

In order to make the required adjustments, particularly in coordination and research promotion, a new law was promulgated in 2008.[58] It modified and supplemented the 1998 Law of Orientation and Programmes for the Development of Scientific Research and Technological Development. This new law attempted to strengthen the national innovation system's components. It declared 30 broad objectives and affirmed the development and application of space techniques as an objective (Article 3). The general report annexed to the new law was more explicit in terms of objectives. It named small satellite technology development (i.e. nano and micro satellites) as a specific R&D objective. The law also enlarged to 34 the number of National Research Programmes (PNRs), including space technologies and their applications (Article 4).

On a biographical note, the author was appointed in 2008 to sit on a committee charged with the preparation of a national research programme on space technologies and their applications. The group's activities were under the coordination of the Ministry of Higher Education and Scientific Research. From 2008 to 2014, the group did not hold any meetings, exemplifying the lack of coordination and group work at national level. It is worth noting that the space programme has been led from inception by the Algerian Space Agency, which was successively under the authority of the prime minister (i.e. head of government), the Minister of Information and Communication Technology, and again that of the prime minister.

Thus, despite the aforesaid efforts and numerous others, deficiencies persist in terms of coordination, research promotion, and industry/R&D collaboration. The construction of an effective and consistent national innovation system has not been successful.[59]

6.2.5 New pressures as a consequence of low oil prices

Since 2014, oil prices have dropped dramatically and have exposed the limits of government economic, industrial and S&T policies. Algeria's economy is still heavily oil-dependent.[60] The government has limited room for manoeuvre. It is difficult to find any scholarly work explaining clearly the strategy adopted by the government to address this critical situation. A new plan for economic growth (2015-2019) has been adopted, introducing some austerity measures. It emphasised the role of the private sector, the importance of SMEs, and management capability development, particularly through international partnerships.[61]

However, the situation is exacerbated by, *inter alia*, the limited awareness Algeria's decision makers possess about capitalism. Inefficient state-owned companies remain protected and central to the strategy. Yet again, rationalisation 'half-measures' have been proposed. The burdensome post-independence legacy of the 'socialist' development model and ideology appears to still prevail in the economic decision-making.[62]

The confusion around the right strategy to adopt is mirrored in the repeated calls by international institutions for Algeria to embark on ambitious reforms.[63] It is also noticeable in the statements made by Algerian officials. For instance, the prime minister (2012-2017) has continually let it be known that the priority is to export, implying that Algeria is adopting an export-oriented regime.[64] His minister for industry, on the other hand, has stated that the industrialisation effort is oriented towards an import substitution regime.[65]

With regard to technological development, it is worth mentioning that the proposed plan for economic growth revisits the importance of innovation. It also explicitly identifies satellite technology as a sector to develop.[66]

6.2.6 Lessons learnt

Based on the above Algerian development trajectory, there is a near-consensus among experts[67] that incorrect choices, inconsistencies, interruptions, short-sighted perspectives, and hesitation in adopting nationwide development policies and strategies have all been constant factors in Algeria's development process. This is evidenced by the poor results obtained under the planned economy model adopted in the initial phase of Algeria's development. It is also evidenced by the inability of Algeria to transition effectively to a market economy. The transition process from a planned to a market economy, initiated in the late 1980s (and the beginning of the 1990s), is not yet complete. Algeria is stuck in transition.

With regard to national technological capability-building, due to the nation's systemic complexity, successfully combining, in a coherent national innovation system, the many enmeshed subsystems with diverse objectives and within multiple contexts has proved to be an enormous challenge for Algeria. Evaluating the national innovation system appears to be challenging, too. Therefore, it would seem appropriate to evaluate Algeria's technological capability-building in a less aggregative manner. The sectoral innovation system perspective brings in additional elements that are peculiar to satellite activities and, consequently, to the present evaluation.

The less aggregative perspective is encouraged by some ‘relatively’ successful sectoral case studies, notwithstanding Algeria’s national-level constraints. These include Algeria’s knowledge-intensive pharmaceutical industry and the remarkable achievements of SAIDAL.[68] This latter is a state-owned company created in 1982 which succeeded in building efficient innovative capabilities. This achievement is a result of sustained government efforts and effective company management, despite existing constraints in terms of resources and market failures.[69]

Likewise, current government efforts to develop the automotive sector,[70] despite lack of public access to a record of results,[71] can bring in additional elements to the evaluation of satellite (or space) innovation systems. Traditionally, the satellite (or space) manufacturing supply chain shares elements (or segments) with the automotive supply chain.

6.3 Algeria’s small satellite capability-building from a process-tracing perspective

What emerges from this brief history of Algeria’s development since independence can be summed up in the following recurring motif: uncertainty in picking choices and failure in the management of development. This is particularly the case because of the range of conflicting interests that a country must balance and the complexity of the challenges faced. Hafsi[72] considers that when causal relationships are obscure, then all solutions are considered equal. He argues that uncertainty comes from the fact that everyone is convinced that his/her opinion is the right one. Therefore, views become difficult to reconcile at the highest level. Thus, he recalls an important principle in the theory of decision making in complex situations: “where opinions are not reconcilable at the highest level, they are more likely to be at a lower level. It is necessary then to avoid taking decisions at the highest level and get them taken at the lower level”.[73]

It is within this context that the idea of building satellite capabilities in Algeria emerged. Indeed, Algeria has been a user of space technology for a relatively long time. Its territory extends over more than 2.3 Million Km², mostly desert. Territory which is difficult and expensive to map and monitor. To cover this territory and to reduce the isolation of remote areas, space technology has long been recognised as a partial solution. The first ground telecommunications satellite station was installed in 1975,[74] and the first satellite images covering Algerian territory were used in the 1980s.[75] Space applications and space techniques began to be taught at university level from the beginning of the 1980s. A specialised (university level) centre for space techniques was set up in the late 1980s.[76]

The recognition of the strategic value of space technology and its application in Algeria has increased over time. In the late 1990s, it reached a level of maturity that made it necessary to move to a new phase. The latter aimed to achieve a greater degree of independence and acquire the means to develop basic space technology. There was a need to move from being a passive ‘user’ to becoming an active ‘developer’. The idea of setting up a National Space Programme with a governing organisation (the Algerian Space Agency) was born.[77]

6.3.1 Small satellites, a lever for building capabilities

The need for developing and framing space activities in Algeria coincided with an international context favourable to the transfer of space technology to developing countries such as Algeria (see chapter 1, Figure 1-2). It in particular coincided with a suitable and advantageous commercial offer on the international market tendered by the UK company SSTL.[78] Algeria seized upon this offer, based on a ‘Know-How Transfer and Training-KHTT’ programme towards small Earth observation satellite manufacture, to take her first steps into satellite manufacturing.[79]

The first small satellite collaborative project was named Alsat-1, which started in 2001.[80] Alsat-1 was designed and manufactured by SSTL over a 15-month collaborative programme involving Algerian engineers and scientists. The Algerians participated in the manufacture and pre-flight testing at SSTL’s facilities in the UK.

The small satellite market had by this time opened up, with new competitive offers being tendered. Algeria accepted one such offer and a second small satellite collaborative project was undertaken. This was the Alsat-2 programme, which started in 2005 with Airbus Defence and Space, previously EADS-Astrium. The project was aimed at developing two identical satellites, Alsat-2A and Alsat-2B. The first, Alsat-2A, was developed by the supplier team with the participation of Algerian engineers in France. The satellite was launched in July 2010. Algerian engineers, based in Algeria, commenced assembly and integration of Alsat-2B in 2012,[81] which was launched in 2016.

In 2014, a third small satellite collaborative project called Alsat-1B was begun with SSTL/UK. In this project, Algerian engineers carried out the integration and test phase of the satellite at Algeria's local facilities.[82] Alsat-1B was launched in 2016.

Algeria used the above three satellite collaborative projects (Alsat-1, Alsat-2, and Alsat-1B) as vehicles for acquiring satellite technology from abroad, with a view towards indigenising it.[83] These projects inspired and served as the backbone for the design of a broader space programme in Algeria.[84] Indeed, their centrality is reflected in the number of actions and projects planned around collaborative projects and around images these satellites provide.

The centrality of satellite collaborative projects can be seen through the word cloud displayed in Figure 6-1. The word cloud was generated on April 2017 by running an NVivo word frequency query over the Algerian Space Agency's -(ASAL) website.[85] The query covered the webpages that publicise ASAL activities as part of the Algerian space programme from January 2010 to March 2017.[1] Figure 6-1 shows that 'alsat' is the most frequently occurring word on ASAL's website. The term 'alsat' is a prefix referring to satellite collaborative projects Alsat-1, Alsat-2, and Alsat-1B. The rest of the cloud's words surround 'alsat'. They mostly refer to activities where satellite images are used for

[1] ASAL often publicises its activities in Arabic and French (and rarely in English). The word frequency query was run over the French version.

satellite applications (forestry, land-use planning, environment and ecology, desertification, water resources, desert locust).

Figure 6-1: Word cloud – ASAL website

Source: Author

6.3.2 Small satellite technology within the burgeoning Space Innovation System

As noted above, the strategic value of space technology and the need for a coordinated effort to mature space capability in Algeria brought into relief the necessity of codifying a sustainable space programme with a leading organisation.[86] This led to the establishment of the Algerian Space Agency in 2002.[87]

The Algerian Space Agency formulated a national space programme in conjunction with various governmental bodies and in accordance with development requirements. The national space programme was adopted by the government on the 28th of November, 2006. It covers a period of 15 years (2006-2020), with five-year reviews. It is the reference programme for space policy in Algeria and represents a governmental support tool for sustainable development and strengthening national sovereignty.[88] The strategic objectives of the programme are threefold: i) development of industrial capabilities; ii) satisfaction of national needs; and iii) knowledge capability-building.[89] The programme laid the foundations of a sectoral Space Innovation System, composed of actors, networks and institutions.

Actors involved in small satellite development

The programme identifies the organisations which are to be involved. Four operational entities[2] were set up under the Algerian Space Agency. One of them is the Centre for Satellite Development (CDS), which is responsible for satellite development. Other organisations are identified and set to be involved in space activities: ministerial departments as users, as well as public research centres, universities, and a few public industrial companies (e.g. aircraft construction company – ECA).

The Centre for Satellite Development is supposed to coordinate the activities of organisations which contribute to satellite development.[90] Certain universities and research centres are identified (the universities of Algiers, Oran, Constantine, Setif, Tlemcen, and the Centre for Development of Advanced Technologies - CDTA). The national space programme remains rather limited in its purview when it comes to identifying local industrial organisations to partner with, particularly those in the private sector. This is due to the fact that no thorough audit of the industrial environment had been undertaken prior to the formulation of the programme.[91] This failure persists 12 years on since the programme was adopted (in 2006); ASAL has only undertaken one limited audit involving the mechanical engineering industry, in 2008.[92] It is important to note that the space programme puts no limitation on collaboration with public and private actors, as well as local and foreign actors (including industrial actors), along vertical and/or horizontal linkages.[93]

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[2] Centre des Techniques Spatiales (CTS), Centre des Applications Spatiales (CAS), Centre d'Exploitation des Systèmes de Télécommunications (CEST), and Centre de Développement des Satellites (CDS). http://www.asal.dz/entites.php (Accessed on 10 March 2017).

Networking of actors

The national space programme envisages linking space actors together in networks around joint projects.[3] Some 68% of these projects are intended to satisfy user needs in terms of space applications (use of satellite images in thematic applications like agriculture, forestry, and the environment).[94] The rest (32%) is dominated by: i) infrastructure projects; ii) training and education projects (a cluster of universities, including a doctoral school specialising in space applications and technologies jointly formed by a consortium of universities - EDTAS);[95] iii) satellite acquisition from abroad (e.g. a telecommunication satellite project); and iv) small satellite collaborative projects with foreign companies (e.g. Alsat-2, Alsat-1B).

Little is explicitly stated in the programme about 'local' technological development (e.g. local development of satellite systems or components). Very little is also explicitly stated about technological and industrial actors, their roles, objectives and networking.[96] This is reflective of the weak linkages ASAL has with the local industrial environment and, beyond that, the weak linkages with national industrial policies that relate to ASAL activities.

This shallow approach with respect to technological and industrial actors might also be reflective of prevailing practices, and corporate culture, in ASAL. Indeed, the human resources component of ASAL is mostly drawn from an academic-type environment (universities or research centres/institutes).[97] It is likely that it has brought with it inherited deficiencies as to university/industry and research/industry linkages typical of developing countries.[98] Moreover, it is likely that it has also brought the inherited deficiencies of organisational learning between knowledge organisations (e.g. linkages between universities, research centres).[99] For instance, the fieldwork identifies the weak linkages ASAL entities have with the doctoral school specialising in space applications and technologies – EDTAS.[100]

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[3] 86 projects are identified. http://www.asal.dz/psn.php (Accessed on 10 March 2017).

Institutions governing interactions between actors

The space programme was devised primarily from a ‘bureaucratic and non-market’ perspective. Actors and interactions that may occur within market networks were absolutely not dealt with.[101] The exclusive source of funding for the programme was always intended to be the state budget. The reason given for this in the particular case of the satellite industry is that it is an ‘infant’ industry requiring significant learning costs and protection.[102] In addition, market competition could stifle capability-building efforts if market failures exist.[103] However, protection would generally be extended for a limited period. Protection was intended to address challenges associated with resource allocation and not all market failures (failures outside organisations, such as institutional and infrastructure inadequacies, and labour market deficiencies). The space programme is now in its twelfth year and questions relating to these aspects still do not appear to have been addressed.[104]

Some national regulations and practices governing interaction between governmental actors were adapted for the space sector. For instance, the framework provided by the Law of Orientation and Programmes for the Development of Scientific Research and Technological Development was used by ASAL.[105] University regulations and practices were adopted for the governance of the doctoral school specialising in space applications and technologies.

As stated previously, the space programme contains virtually no explicit institutional policies intended to shape networks and interactions between industrial actors. Indeed, the programme identifies ASAL and its operational entity CDS[4] as ‘prime movers’ or ‘system builders’ for the development of satellite technology.[106] It remains vague as to what should be the means of involving local actors, particularly those supposed to contribute to the development of satellite technology. For instance, no reference is made as to

[4] Centre for Satellites Development -CDS

how technology should be transferred from CDS to local industrial actors. No programme of accompanying policies exists for upgrading local actors to comply with space industry requirements. The vital issue of intellectual property rights is also grossly neglected. Incentives towards local actors and funding options are not addressed. [107] In short, policies and actions intended to build local industrial capabilities for the development of satellites are vague or non-existent.

By contrast, the space programme leaves plenty of room for space applications that target the use of satellite images.[108] More than 15 ministerial departments are presently involved as users of satellite images, and more than 50 application projects are based on satellite images.[109]

Successful technological policies are based on three interrelated types of measures:[110] i) policies intended to create and foster market needs for the technology in question (e.g. need for satellite images), known as demand-side strengthening – the space programme does indeed promote this aspect; ii) policies intended to build technological capabilities (e.g. build satellites that satisfy certain needs), known as supply-side strengthening – the space programme obliquely addresses this aspect; and finally, iii) policies intended to link both the demand and supply side – the space programme does not address this aspect.

ASAL finds itself in a lopsided position typical of developing countries, where users (or market) demand more technological products (e.g. satellite images) and the supplier does not have the technological capability to deliver them. This makes it difficult, nay impossible, for ASAL to devise policies that effectively link demand to supply.

Learning type fostered in the space programme

The 'knowledge-base' is sometimes discussed as the fourth element of a technological innovation system.[111] It is important because it provides guidance on the precise learning that needs to take place for building local capabilities. In general, technological capability-building refers to building complementary and balanced capabilities in engineering, development, and research. The adopted capability-building policy should be adjusted to a particular need. For instance, if there is a need for learning by searching (i.e. research activity) (see chapter 2, subsection 2.4.5), the capability-building policy should promote investment in research. On the other hand, if there is a need for learning by doing (i.e. engineering activity), the policy should encourage market growth. [112]

The Algerian space programme takes an off-balance approach when it comes to satellite development.[113] Learning by searching (or research investment) appears to be addressed by enlisting the services of research centres and universities. This is, indeed, commendable given the highly knowledge-intensive and high-risk nature of satellite technology. Basic research and public research organisations have an important role to perform in complementing applied research and development activities. However, the latter, along with engineering, are made less explicit in the space programme. As mentioned earlier, their actors, networks (enabling learning by interacting - see chapter 2, subsection 2.4.5), and institutional measures are virtually not addressed.

The satellite sector imbalance identified in ASAL's planned strategy on research, development, and engineering, is reminiscent of Algeria's national imbalance in the 1970s, described above in section 6.2.1. Indeed, strategic emphasis appears to be almost exclusively placed on research activities. Development and engineering activities, by contrast, are insufficiently well addressed. This leads, almost inevitably, to a system that is biased towards research activities and disconnected from development and engineering aspects (i.e. scientific and basic research disconnected from technological and applied research). This issue is not unique to the satellite sector: the Ministry of Industry has recently (in 2017) pointed out that the whole National Innovation System is skewed in favour of research activities.[114]

6.4 Planning of small satellite capability-building

The foregoing section underlined the role of satellite collaborative projects as a vehicle for acquiring satellite technology in Algeria. It identified imbalances between actions geared towards research, development and engineering in the satellite programme. Similarly, it highlighted the imbalance between actions targeting satellite applications and satellite technology development. The imbalances reflect the difficulty, or confusion, ASAL has in perceiving and managing interactions and cross-linkages across the battery of activities required to build small satellite capability.

From a strategic planning perspective, this confusion reflects limitations in establishing strong linkages between planning levels. Moreover, given the centrality of satellite collaborative projects in building satellite capabilities, the observed confusion might equally be reflective of a non-alignment of ASAL's strategy with collaborative projects (or the project portfolio).[115] In other words, the projects should be embedded into ASAL's strategy, and if the strategy is not well thought through, it is difficult to assess whether the collaborative projects suit the strategy and how closely aligned they are to it.

This section therefore examines how rigorous the planning of small satellite capability-building has been.

The fieldwork reveals the vagueness surrounding the process used by ASAL when planning small satellite capability-building in Algeria. No recognised and 'rigorous' process such as the 'strategic planning'[116] was used for planning.[117] Consequently, a lot of gaps exist in the strategic roadmap; that is, the National Space Programme devised by ASAL. One of the strategic objectives of the latter is the development of small satellite industrial capabilities. In order to attain this objective, first, ASAL should have assessed its situation by appraising its external and internal environment.

6.4.1 Assessment of external and internal environment

To assess the external environment, data should be collected on the character of and trends present in the industrial environment, including competitors, suppliers, partners and funders. Data should also be collected on the macro-environment (i.e. PESTEL: Political, Economic, Social, Technological, Environmental and Legal). Analysis of the national space programme along with interviews conducted with ASAL's senior-management echelon reveals limited assessment of the external environment.[118] As mentioned earlier, no thorough audit of the industrial environment had been undertaken prior to the formulation of the space programme and even during its implementation. Aspects related to intellectual property rights were grossly neglected. The exclusive source of funding was the state budget, and no other funding options were contemplated. With the state budget now shrinking as a consequence of low oil prices, ASAL faces a real challenge in funding its activities.

Deficiencies observed in the assessment of the external environment might be partly explained by the nature and status of ASAL and its staff. It is a governmental organisation, hence the emphasis is on its mission of public service (e.g. need to provide satellite images, training) and certain political objectives (e.g. sovereignty, prestige, public image). Other considerations such as markets, economic return, financial return and business environment do not receive enough attention.

With regard to the internal environment, data should be collected on existing internal capabilities, such as organisational structure, human resources, material resources, and facilities required for satellite exploitation, engineering, development and research. The fieldwork reveals that internal environment assessment was centred on exploitation activities and, to a lesser extent, on research activities.

Internal capabilities in terms of engineering and development were not properly assessed.[119] A zero-based approach was adopted, based on the judgement that engineering and development capabilities had to be built from scratch. For instance, putting in place a new organisational entity (i.e. CDS), building new facilities, acquiring new equipment, recruiting and training new human resources.[120] This incomplete approach has consequently blurred connectivity between existing and intended capabilities in terms of engineering and development (see chapter 7). This is important as the spearhead of satellite development capabilities in Algeria was the collaborative projects, which are engineering and development projects par excellence.

6.4.2 Assessment of strategic direction, according to organisational capacity

The previous section suggested that ASAL did not rigorously assess its external and internal environment. It is likely, therefore, that it has defined its strategic direction, in terms of building small satellite industrial capabilities, based on a distorted vision of its strengths, weaknesses, opportunities and threats. The relative opacity of ASAL's organisational potential was reflected, during the fieldwork, by difficulties present in identifying a clear strategic direction for the development of the satellite industry. The majority of interviewees (70%) at senior- and mid-management level could not respond clearly to the question "Where do you (i.e. ASAL) want to be in the future?" This is indicative of a lack of strategic vision, and a lack of communication within the organisation.

Moreover, interviewee responses were disconnected from data related to the external and internal environments. For instance, many of the interviewees (40%) highlighted ASAL's strategic direction for building an indigenous satellite platform (see chapter 3, subsection 3.2.1).[121] It is apposite to note that mechanical engineering knowledge is of crucial importance when it comes to building a satellite platform's structure. Yet, data collected during the fieldwork show that mechanical engineering knowledge is one of the weakest aspects of ASAL's internal capabilities (lack of human resources in mechanical engineering, lack of equipment, lack of R&D activities).[122]

6.4.3 Assessment of action plan and related project portfolio

In a properly articulated process of strategic planning, strategic direction should be the basis for developing an action plan and a related projects portfolio in an organisation.[123] In the case under study, however, strategic direction for building satellite industrial capability is not clearly defined, as noted above. It is therefore not altogether surprising that the action plan was also found wanting, i.e. lacked clarity. When inquiring into the latter, the most common response given by interviewees at senior- and mid-management level (85%) was that ASAL pursues actions that enable "step-by-step access to satellite technology". The corresponding French phrase very often heard in the course of the fieldwork was "Accéder par palier à la technologie."[124] This very same generic phrase is found in documents related to the national space programme.[125]

According to interviewees,[126] the implicit two steps required to access (or transfer) technology were: Step 1: Algerian engineers partook in the manufacturing tasks of Alsat-1 and Alsat-2A at the facilities of the suppliers, and Step 2: they undertook the assembly, integration and test tasks of Alsat-2B and Alsat-1B at ASAL's own facilities. It is significant that the generic phrase "step-by-step access to satellite technology" is translated by ASAL exclusively through actions related to a portfolio of satellite collaborative projects (with foreign companies), again underlining their centrality in the process of building a satellite industry. No other actions or projects (other than collaborative projects) have been identified during the fieldwork.

In addition, even with regard to the somewhat narrow collaborative projects portfolio, the fieldwork reveals inaccuracies in the supposedly SMART[127] criteria (where goals should be Specific, Measurable, Agreed-upon, Realistic, Time-based) that should accompany an action plan or projects portfolio in the planning process. For instance, no specific target is defined, no specific technology is targeted, with only very generic metrics defined and an inaccurate schedule proposed (several actions had been delayed as revealed in chapter 7, section 7.1.2). Put differently, very loosely articulated goals were explicitly stated by ASAL in the planning process. Similarly, actions are loosely cascaded across organisational, functional and individual levels. Interviews conducted at micro and meso level reveal the non-existence of clear action plans for individuals, groups, and even organisations involved in building industrial capabilities.[128] For instance, ASAL, as the parent organisation, formally entrusted the mission of satellite development to its operational entity CDS (Centre for Satellite Development). The fieldwork reveals (see chapter 7) that CDS had no clear action plan for this purpose and ASAL kept a close control over the process, and even micro-managed it.

It is clear therefore that the planning of small satellite capability-building was loosely carried out at central level, evincing virtually no connectivity with operational activities. Obviously, as shown in chapter 7, this major weakness has negatively affected actor mobilisation during the implementation of the plan.

6.5 Key findings of the planning evaluation

From the foregoing analysis, the major findings of the evaluation of the planning process of small satellite capability-building are summarised in Tables 6.2, 6.3 and 6.4, corresponding to macro, meso and micro levels. The key aspect revealed is ASAL's non-adoption of a rigorous planning methodology. As a consequence, the macro, meso and micro planning levels are not aligned.

Table 6-2: Macro planning evaluation

Key findings
-The strategic directions for satellite industry development are not clear -There are two distinct and disconnected (not coordinated) planning processes, a primary process led by ASAL, and a secondary process led by the Ministry of Higher Education and Scientific Research -The planning is incomplete and based on an incomplete assessment of the external and internal environment -The national space programme is vague in planning the sectoral satellite innovation system (i.e. there is vagueness in the identification and involvement of actors, their networking and institutions) -The action plan at this level is loosely defined

Source: Author

Table 6-3: Meso planning evaluation

Key findings
-The action plan is based on an incomplete assessment of the internal environment -The action plan at this level is loosely cascaded (for the purposes of implementation) -The action plan is ASAL-centred, essentially involving ASAL's internal capabilities and overlooking the external environment -The action plan is off-balanced as the majority of actions are application-centred (e.g. satellite exploitation) or research-centred, overlooking engineering and development activities

Source: Author

Table 6-4: Micro planning evaluation

Key findings
-The action plan at this level is loosely cascaded (for the purposes of implementation) -The action plan is off-balanced as collaborative projects (based on a significant foreign contribution) are the only actions identified, rather than a portfolio of diversified projects that require indigenous effort -The satellite collaborative projects are inaccurately planned -The non-existence of clear action plans for teams and individuals

Source: Author

References and Notes

[1] Benbitour, A., 2011. Les élites algériennes face à la crise : réflexion et un programme. In Hafsi, T.,(Ed). Le développement économique de l'Algérie : Expériences et perspectives. Casbah Editions, pp.176-183.

[2] Ibid.

[3] Djeflat, A., 2012. L'Algérie, du transfert de technologie A l'économie du savoir et de l'innovation : Trajectoire et perspectives. Les Cahiers du Centre de Recherche en Economie Appliquée pour le Développement–CREAD 100, pp.71-100.

[4] Lamiri, A., 2013. La décennie de la dernière chance : émergence ou déchéance de l'économie algérienne. Chihab Editions, pp.25-32.

[5] Lamiri (2013), op. cit.

Djeflat (2012), op. cit.

Saad, M., Zawdie, G., 2005. From Technology Transfer to the Emergence of a Triple Helix Culture: The Experience of Algeria in Innovation and Technological Capability Development. Technology Analysis & Strategic Management 17(1), 89-103.

[6] Ibid., p.56.

[7] Gérard Destanne De Bernis is a French Marxist economist (1928-2010). His main contributions to the economic analysis are the development of a theory of development (1950-1960) and the implementation of an original analysis of capitalism in terms of regulation (1970-1990). In Development Economics, De Bernis introduced the concept of "industrialising industry". The idea put forward is that some industries (mainly heavy) can play a leading role in the development of an economy. This concept is inspired by the idea of a growth pole defended by other economists. In general, De Bernis defended the idea of self-reliance, and the establishment of a process of internal development in the country, "relatively" independent from external factors. This idea fitted the 'vision' of the Algerian ruling class perfectly.

[8] Lamiri (2013), op. cit., pp.57-69.

[9] Ibid.

[10] Djeflat (2012), op. cit.

[11] Saad & Zawdie (2005), op. cit.

[12] Ibid.

[13] Ibid.

[14] Ibid., p.92.

[15] Ibid., pp.89-103.

[16] A Quick process of institutional construction had been initiated mainly by the Ministry of Higher Education and Scientific Research (MESRS). For instance, the creation of the National Research Council (Conseil National de la Recherche-CNR), the Department of Scientific Research (Département de la Recherche Scientifique-DRS), the National Office of Scientific Research (Office National de la Recherche Scientifique-ONRS).

Beddek, F., 2012. Essai sur le système national d'innovation algérien et ses déterminants. Magister dissertation, Faculty of Economic Sciences, University of Oran Es Sénia. Seconde reference in Djeflat (2012), op. cit.

[17] Djeflat (2012), op. cit.

[18] Oufriha, F.Z., Djeflat, A., 1990. Industrialisation et transfert de technologie dans les pays en développement : le cas de l'Algérie. OPU/Publisud, Paris/Alger.

[19] Figures and comparaison given by Lamiri (2013), op. cit., pp.57-69.

[20] Ibid.

[21] Ibid.

[22] Ibid.

[23] Ibid.

[24] Kasmi, D., 2008. Diagnostique économique et financier des programmes de stabilisation et d'ajustement structurel de l'économie Algérienne. Doctorate thesis, University of Lyon Lumière. Second reference in Lamiri (2013), op. cit., p.69.

[25] Lamiri (2013), op. cit., pp.57-69.

[26] Ibid.

[27] Ibid., pp.69-77.

[28] Ibid.

[29] Ibid.

[30] Ibid.

[31] Ibid.

[32] Ibid.

[33] Ibid.

[34] Djeflat (2012), op. cit.

[35] Ibid.

[36] Lamiri (2013), op. cit., pp.69-77.

[37] Ibid.

[38] Ibid., pp.75-77

[39] Saad & Zawdie (2005), op. cit.

Djeflat (2012), op. cit.

[40] Law, n° 98-11 of 22 August 1998, of Orientation and Programmes dealing with the five years plan for the development of scientific research and technological development (Loi d'Orientation et de Programme à Projection Quinquennale sur la Recherche Scientifique et le Développement technologique) 1998-2002.

[41] Djeflat (2012), op. cit.

[42] John Maynard Keynes (1883-1946), British economist and government adviser. Keynes believed that active government intervention in the marketplace was the only method of ensuring economic growth and stability. He held essentially that insufficient demand causes unemployment and that excessive demand results in inflation. Government should therefore manipulate the level of aggregate demand by adjusting levels of government expenditure and taxation. For example, to avoid depression Keynes advocated increased government spending and easy money, resulting in more investment, higher employment, and increased consumer spending. http://www.businessdictionary.com/definition/Keynesian.html (accessed on 27/05/2016)

[43] Lamiri (2013), op. cit., pp.77-86.

[44] Ibid.

[45] Ibid.

[46] Such as, growth of 5.5% in 2002-2010, inflation rate of 2.5%, unemployment rate from 27% in 1999 to 10.3% in 2009, external debt less than 4.8 billion US dollars in 2009. Lamiri (2013), op. cit., pp.77-86.

[47] Such as :

Mebtoul, A., 2011a. Bilan des politiques économiques de 1963 à 2010. In Hafsi, T., (Ed). Le développement économique de l'Algérie : Expériences et perspectives. Casbah Editions, pp.47-71.

Mebtoul, A., 2011b. L'Algérie de 2010 : Une transition perturbée. In Hafsi, T., (Ed). Le développement économique de l'Algérie : Expériences et perspectives. Casbah Editions, pp.75-100.

Lamiri (2013), op. cit., pp.77-86.

Sari, C., 2011. Algérie et Maroc : Quelles convergences économiques ? Cabrera Editions, pp.141-244.

[48] Because:

-Keynesian-type government capital spending is a way to solve problems in the short term rather than long term, whereas Algeria is using it as a long term solution (throughout the three plans). Keynes argues that governments should solve problems in the short run rather than waiting for market forces to do it in the long run, because, "in the long run, we are all dead".

Keynes, J.M., 1924. The Theory of Money and the Foreign Exchanges. A Tract on Monetary Reform. Macmillan and Co., Limited, London.

Summary published in http://www.newworldencyclopedia.org/entry/Keynesian_economics (Accessed on 25 January 2015).

-Keynesianism has no validity in developing countries because Keynesian economics is based on assumptions which limit its applicability to underdeveloped countries.

Chand, S., "Applicability of Keynes' Theory to Underdeveloped Countries". Article published in http://www.yourarticlelibrary.com/macro-economics/theories-macro-economics/applicability-of-keynes-theory-to-underdeveloped-countries/30983/ (Accessed on 25 January 2015).

Dasgupta, A.K., 1954. Keynesian Economics and Underdeveloped Countries. The economic weekly, pp.101-105.

Perroux, F., 1966. Le Multiplicateur d'investissement dans les pays sous-développés. Tiers-Monde 7(27), pp.511-532. He argues that Keynesianism has no validity in under-developed countries. Second reference in Lamiri (2013), op. cit., p.81.

[49] For instance:

Algeria's rank is 163 in Doing Business 2016 ranking http://www.doingbusiness.org/data/exploreeconomies/algeria (Accessed on 14 March 2017).

Algeria's rank is 103 in ICT Development Index (IDI) 2016 ranking http://www.itu.int/net4/ITU-D/idi/2016/#idi2016rank-tab (Accessed on 14 March 2017).

Algeria's rank is 83 in the UN Human Development Index 2015 ranking http://hdr.undp.org/en/countries/profiles/DZA (Accessed on 14 March 2017).

Number of companies created during the first nine months of 2016 is 12 168 (3 766 in services, 3 730 in goods production, 2 028 in import, 1 386 in retail distribution, 1 350 in wholesale distribution, and 209 in export). http://www.radioalgerie.dz/news/fr/article/20161127/95351.html (Accessed on 14 March 2017).

Algeria's rank is 87 in The Global Competitiveness Index 2015–2016 Rankings. http://www3.weforum.org/docs/gcr/2015-2016/Global_Competitiveness_Report_2015-2016.pdf Report, page 94 (Accessed on 14 March 2017).

[50] For example:

Mebtoul (2011a), op. cit.

Mebtoul (2011b), op. cit.

Lamiri (2013), op. cit., pp.77-86

Sari (2011), op. cit., pp.141-244.

Bruno Lanvin, interview of representative of the World Intellectual Property Organization to Econews,

http://www.leconews.com/fr/actualites/nationale/industries/l-algerie-peut-conforter-sa-position-comme-un-lieu-ou-se-forge-le-transfert-de-technologie-30-01-2013-161940_340.php (Accessed on 26 January 2015).

Algeria's stage of development in The Global Competitiveness report 2015–2016, page 94, http://www3.weforum.org/docs/gcr/2015-2016/Global_Competitiveness_Report_2015-2016.pdf (Accessed on 14 March 2017).

Pascal Lamy, former Director of the World Trade Organization (WTO). https://www.tsa-algerie.com/lex-patron-de-lomc-critique-severement-lalgerie-consideree-comme-un-contre-exemple/ (Accessed on 11 April 2017).

51 Dutch disease can be defined as "the negative impact on an economy of anything that gives rise to a sharp inflow of foreign currency, such as the discovery of large oil reserves. The currency inflows lead to currency appreciation, making the country's other products less price competitive on the export market. It also leads to higher levels of cheap imports and can lead to deindustrialization as industries apart from resource exploitation are moved to cheaper locations. The origin of the phrase is the Dutch economic crisis of the 1960s following the discovery of North Sea natural gas." Definition taken from Financial Times Lexicon: http://lexicon.ft.com/Term?term=dutch-disease (Accessed on 26 January 2015).

52 Such as Lamiri (2013), op. cit., pp.89-90.

53 Such as Sari (2011), op. cit., p.156.

54 Djeflat (2012), op. cit.

55 Ibid.

56 Ibid.

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Mebtoul (2011b), op. cit.

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[79] Internal documentation of the ''Conseil National de l'Information Géographique – CNIG''.

[80] http://www.sstl.co.uk/Missions/AlSAT-1--Launched-2002/AlSAT-1/AlSAT-1--The-Mission and http://www.asal.dz/Alsat%201.php (Accessed on 26 January 2015)

[81] http://www.space-airbusds.com/en/programme/alsat-2-fbe.html , http://www.asal.dz/Alsat%202A.php , and http://www.asal.dz/lancement-alsat-algerie.php (Accessed on 10 March 2017)

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[89] http://www.asal.dz/psn.php (Accessed on 10 March 2017)

[90] Interview: ID-39 (July 2016)

Interview: ID-41 (April 2016)

[91] Interview: ID-37 (July 2016)

[92] Interview: ID-39 (July 2016)

Interview: ID-37 (July 2016)

Interview: ID-41 (April 2016)

[93] Interview: ID-47 (August 2016)

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[94] http://www.asal.dz/psn.php (Accessed on 10 March 2017).

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[118] Internal documentation (National Space Programme).

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Interview: ID-37 (July 2016)

[119] Internal documentation (National Space Programme).

Interview: ID-37 (July 2016)

[120] Internal documentation (National Space Programme).

Interview: ID-48 (August 2016)

Interview: ID-37 (July 2016)

[121] Interview: ID-48 (August 2016)

Interview: ID-41 (April 2016)

[122] Interview: ID-41 (April 2016)

Interviews conducted with members of the small satellite project teams (April, May, July, August 2016).

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Interview: ID-37 (July 2016)

Interview: ID-36 (April 2016)

Interview: ID-41 (April 2016)

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Chapter 7: Implementation of Algeria's small satellite capability-building programme

Chapter 6 provided the contextual backdrop to Algeria's technological development and laid out key elements of the burgeoning Satellite (or Space) Innovation System. It also evaluated the planning of the small satellite capability-building programme in Algeria.

As discussed, three small satellite collaborative projects (Alsat-1, Alsat-2, and Alsat-1B) formed the backbone for technology acquisition and building local capabilities. Alsat-1 and Alsat-1B are two small satellites built in 2000 and 2014 respectively in conjunction with SSTL-UK. Alsat-1 and Alsat-1B were launched in 2002 and 2016 respectively. Alsat-2 comprises a pair of identical satellites (Alsat-2A & B) built jointly with Airbus-France. The Alsat-2 project is perceived as one system, as most project phases were started in 2005 and involved both satellites. Alsat-2A was completed and launched in 2010, whereas the integration and test phase of Alsat-2B commenced in 2012. Alsat-2B was launched in 2016.

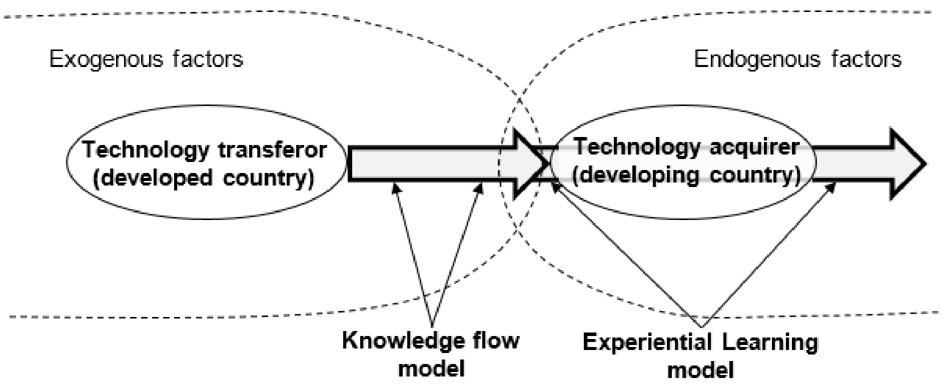
The present chapter follows on from chapter 6 by way of evaluating the implementation of the capability-building programme from individual and team level through to organisational and, ultimately, inter-organisational levels. The chapter critically analyses the programme's implementation according to three categories of evaluation metrics. Section 7.1 addresses technological learning occurring during and after the collaborative projects' completion. Section 7.2 evaluates the locally built technological capabilities, mostly relating to endogenous factors. Lastly, section 7.3 complements the latter by evaluating the transferor-transferee interface via metrics reflective of exogenous factors.

7.1 Learning occurring during the capability-building process

Technological learning is at the heart of this study. Its evaluation is conducted via the implementation of two systemic models described in chapter 4 (sections 4.3 and 4.4).

The first of these models is the 'knowledge flow model'. It evaluates learning that occurred during the collaborative projects Alsat-1, Alsat-2, and Alsat-1B, used to transfer technology to Algeria. The second model is the 'experiential learning model'. It evaluates learning occurring within the Algerian Space Agency setting, following implementation of the three collaborative projects. The sequential use of these two models traces knowledge flow from its acquisition from abroad to its diffusion locally (Figure 7-1).

Figure 7-1: Positioning of the two evaluation models



Source: Author.

7.1.1 Learning during the projects' lifetime - implementation of the 'knowledge flow model'

The model is applied to the three collaborative small satellite projects Alsat-1, Alsat-2 and Alsat-1B. Small satellite systems can be divided into a ground and space segment (see chapter 3, subsection 3.4.1). The space segment refers to the satellite itself (or a constellation of satellites like Alsat-2A & B). The ground segment refers to the components used to operate the satellite once in orbit so as to receive and process data (satellite images).

Knowledge flow with regard to the ground segment is not evaluated in this section as the focus of all Algerian collaborative projects has been on the space segment. Ground segments were acquired only for the exploitation of space segments. No joint development or integration activities were carried out around ground segments.

Accordingly, in the following subsections, the knowledge flow model is applied only to the space segment (i.e. satellite), as the bulk of joint development and integration activities were carried out on the satellite. Eight (08) components of the satellite are identified and referred to as $C_{1,}$ $C_{2,...,}$ C_8 in Table 7-1.

Table 7-1: Components of the jointly developed satellites

Segment	**Satellite**							
	Platform							**Payload**
Components	**Structure**	**Thermal control**	**On-board power supply**	**Attitude control**	**Data handling**	**RF**	**Propulsion**	**Payload**
Component Codes	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8

Source: Author

a. Model implementation on Alsat-1 project

As detailed in chapter 4 (subsection 4.3.3, equation (10)), the transferred knowledge is $KT_0 = KVis_0 + KVel_0$. $KVis_0 = I_0$, providing an indication of the depth of integrative knowledge required to put satellite components $C_{1,}$ $C_{2,}$ …, C_8 together. $KVel_0 = C_1 + C_2 + ... + C_8$ and provides an indication on the breadth of the transferred knowledge during the project's lifetime. It is reflected through the number of components involved in the transfer process along with the depth of knowledge associated with each component.

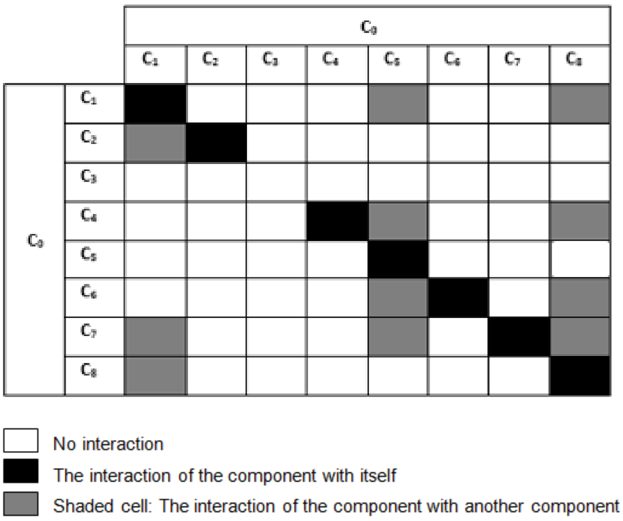
a.1. Measuring the depth of integrative knowledge

The depth of integrative knowledge is measured using two metrics: the intensity of interactions between Algerian team members (as a proxy for group work), and their degree of involvement during the project in the integration and test operations.

The N^2 diagram (Figure 7-2) is used to illustrate these interactions. This matrix is compiled from responses to questions about joint tasks shared amongst individual team members in the course of the project. The shaded cells indicate how each component (or individuals in charge of it) interacts with the others. Interaction is defined from 0 (Low) to 1 (High). The following assumption is made: full integrative knowledge is attained when the acquirer knows how all components in the matrix interact with one another (i.e. 8x8 cells are shaded) and total interaction is then expressed by the ratio (number of shaded cells/total cells =) 64/64=1.

For Alsat-1 team members, interaction is depicted in Figure 7-2. The score is thus: number of shaded cells/total cells = 19/64 = 0.29

Figure 7-2: Interaction matrix Alsat-1



Source: Author

To ascertain degree of involvement in the integration (putting components together) and test operations, each team member was questioned (see questionnaire in appendix 1-a) regarding their level of involvement during the project. On a scale of 0-to-1, participants gave an average rating of 0.37.

Consequently, the depth of integrative knowledge for Alsat-1, referred to 1, is given by $KVis_0 = I_0$ = (interaction score + involvement score)/2 = (0.29 + 0.37)/2 = 0.33

a.2. Measuring the breadth of knowledge

The transferred component knowledge, or breadth of knowledge transfer, during the project is reflected in the number of components involved in the transfer process, along with the depth of knowledge associated with each component.

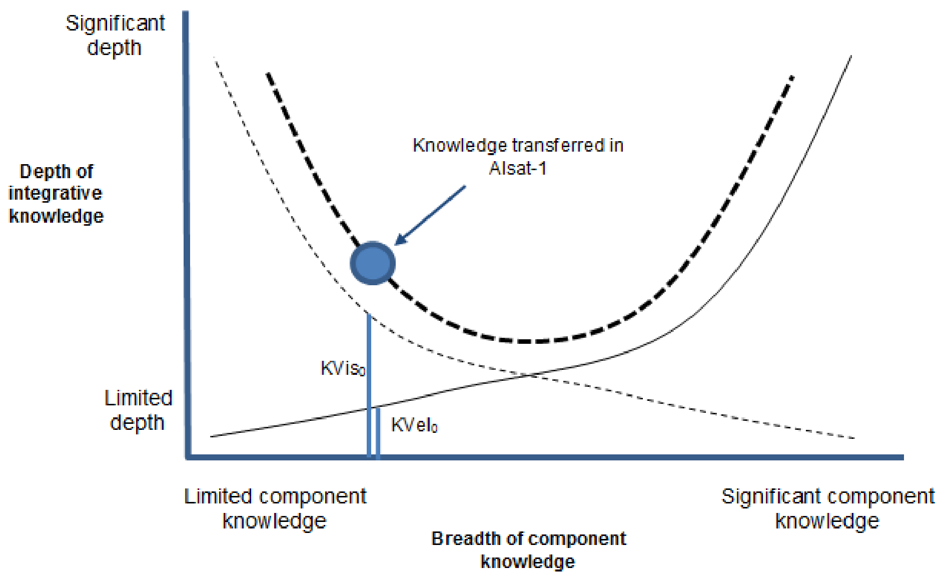
Eight (08) components were made use of in the Alsat-1 project, corresponding to the highest component score (=1). With respect to the depth of knowledge of each component, this is measured through questions about the actual number of Algerian engineers who participated in the development of each component compared to the required number for the development of the component, *ceteris paribus*. According to the participants, 65 individuals are typically required by SSTL-UK to build all the components of the system, whereas only eight (08) Algerian engineers took part in this project. This gives the following ratio: number of Algerian engineers/the required number = 8/65 = 0.14

Consequently, breadth of knowledge for Alsat-1 is $KVel_0 = C_1 + C_2 + ... + C_8$ = actual number of participants / required number of participants = 8/65= 0.14

a.3. Graphical representation of the knowledge flow

The transferred knowledge for the satellite Alsat-1 is given by $KT_0 = KVis_0 + KVel_0 = 0.33 + 0.14 = 0.47$ (Figure 7-3)

Figure 7-3: Knowledge flow in Alsat-1 project



Source: Author

b. Model implementation on Alsat-2 and Alsat-1B projects

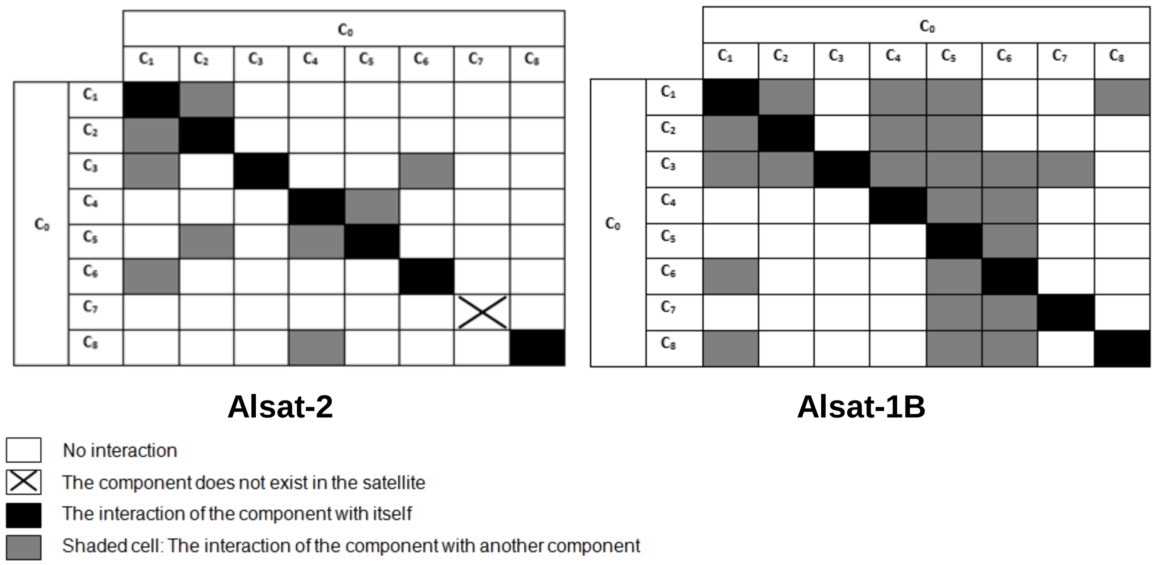
The steps outlined above for the implementation of the model on the Alsat-1 project were implemented on both the Alsat-2 and Alsat-1B projects. Table 7-2 summarises the value of the transferred knowledge according to the proposed model. Figure 7-4 shows interaction matrices of Alsat-2 and Alsat-1B.

Table 7-2: Knowledge flow values of Alsat-2 and Alsat-1B

Alsat-2		**Alsat-1B**	
$KVis_0$ Depth of integrative knowledge = (0.25+0.90)/2=0.57	Intensity of interactions = 0.25	$KVis_0$ Depth of integrative knowledge = (0.5+0.65)/2=0.57	Intensity of interactions = 0.5
	Degree of involvement = 0.90		Degree of involvement = 0.65
$KVel_0$ Breadth of knowledge = 0.11	Number of components = 7	$KVel_0$ Breadth of knowledge = 0.18	Number of components = 7
	The ratio number of Algerian engineers/the required number = 8/70=0.11		The ratio number of Algerian engineers/the required number = 13/70=0.18
Prior knowledge	0.62		0.78
$KT_0 = KVis_0 + KVel_0$ = 0.57+0.11=0.68		**$KT_0 = KVis_0 + KVel_0$ = 0.57 + 0.18 = 0.75**	

Source: Author

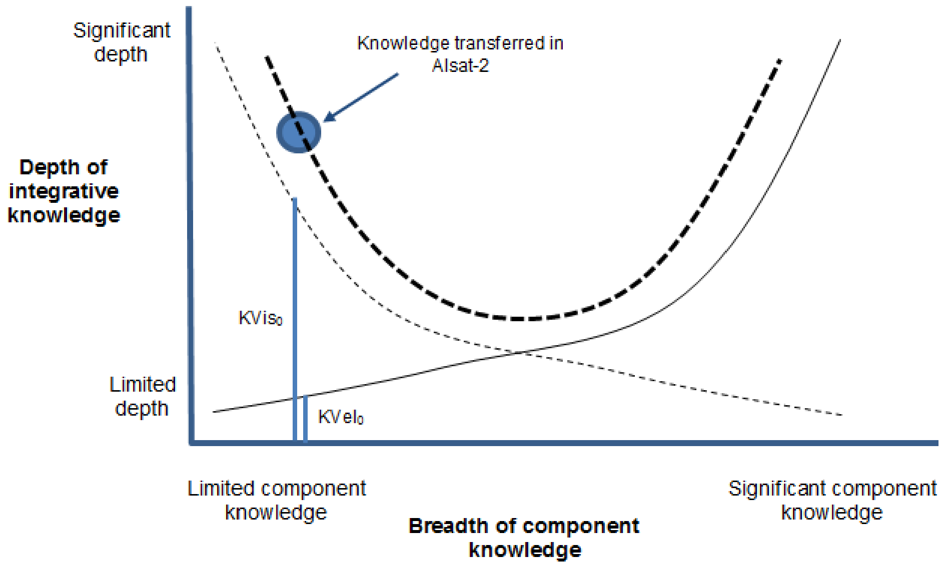
Figure 7-4: Interaction matrices of Alsat-2 and Alsat-1B



Source: Author

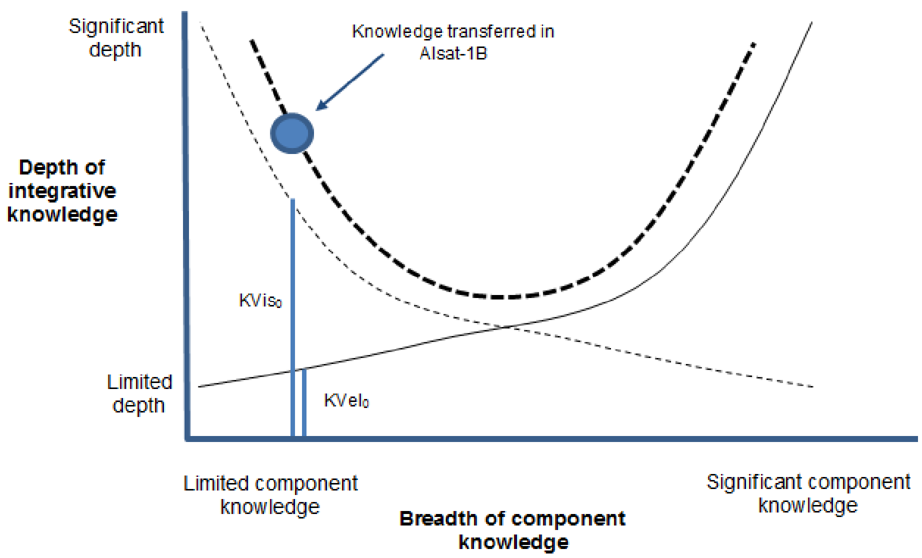
Based on the values in Table 7-2, graphical illustrations of knowledge transferred (knowledge flow) in the Alsat-2 and Alsat-1B projects are presented in Figures 7-5 and 7-6.

Figure 7-5: Knowledge flow in Alsat-2 project



Source: Author

Figure 7-6: Knowledge flow in Alsat-1B project

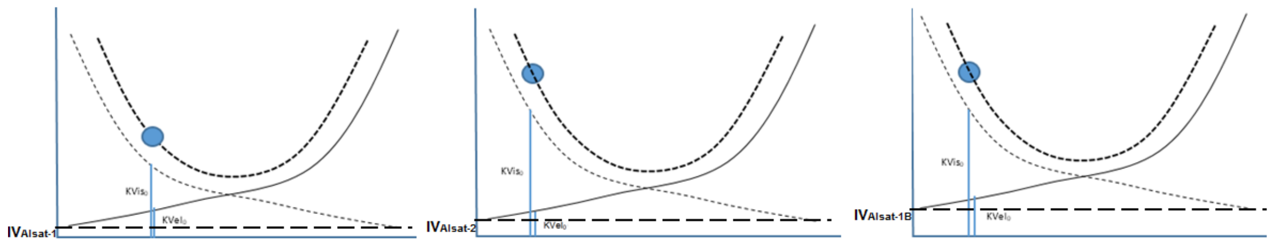


Source: Author

c. Impact of transferee absorptive capacity on knowledge flow

The graphical representation of the knowledge flow model applied to the three projects analysed shows that there are shifts in terms of initial values on the ordinate axis. These shifts relate to the initial value of knowledge. These shifts are denoted 'IV' (for initial value) and highlighted in Figure 7-7. Even though the shifts are not significant, the graphical representation shows that $IV_{Alsat\text{-}1B}$ > $IV_{Alsat\text{-}2}$ > $IV_{Alsat\text{-}1}$.

Figure 7-7: Effect of absorptive capacity



Alsat-1 **Alsat-2** **Alsat-1B**

Source: Author

The author contends that the initial value of knowledge is correlated to the absorptive capacity of learners involved in the satellite projects. An attempt is made below to estimate the value of the absorptive capacity of learners in the projects, where AC denotes absorptive capacity. This capacity results from the prior knowledge possessed by the learner (denoted by PK) and the intensity of effort invested in the learning process (denoted by Inty).[1] Consequently, it can be posited that the learner's absorptive capacity is:

$$AC = PK + Inty \qquad (14)$$

Prior knowledge (PK) is measured through an evaluation of the academic and professional background of participants in the project, the preparatory activities ahead of the project, and the appropriateness of knowledge possessed to requirements during the project (see questionnaire in appendix 1-a). On a scale of 0-to-1, the average PK ratings in the three projects are: $PK_{Alsat-1} = 0.58$, $PK_{Alsat-2} = 0.62$, and $PK_{Alsat-1B} = 0.78$

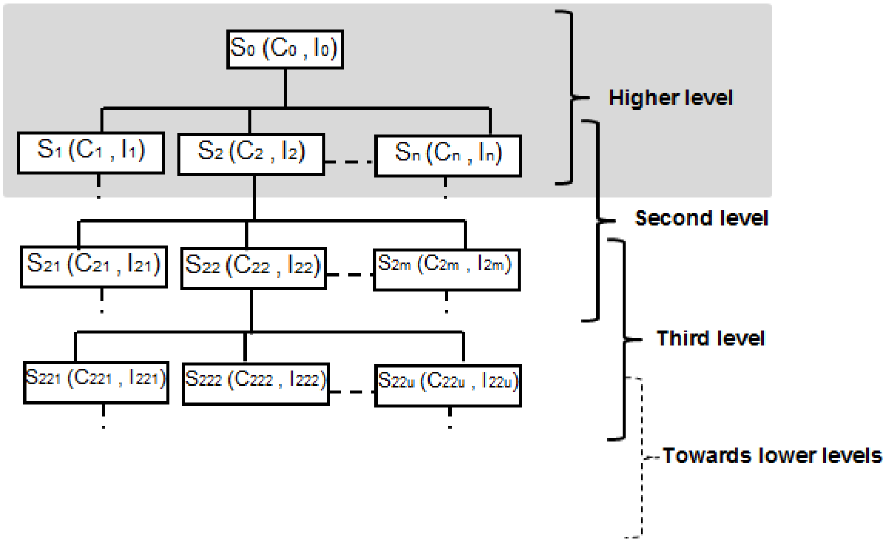
With regard to the intensity of learning effort, it is important to recall that technological knowledge includes two complementary elements, tacit and explicit knowledge. Intensity of effort is then a combination of the intensity of tacit learning and the intensity of explicit learning. Due to the difficulty of estimating the two elements and their appropriate combination quantitatively, intensities of effort during the three projects are assumed to be similar.

Consequently, learners' absorptive capacity is reflected only in the prior knowledge of learners on each project. It is thus apparent that the prior knowledge in Alsat-1B ($PK_{Alsat-1B} = 0.78$) is more significant than that in Alsat-2 ($PK_{Alsat-2} = 0.62$) and Alsat-1 ($PK_{Alsat-1} = 0.58$). The increase over time reveals a tendency towards improving the prior knowledge of participants in projects. This has been confirmed, as managerial-level participants in this empirical study have pointed out the improvements in the selection process of team members and their preparation for the project.[2]

d. Findings from the implementation of the 'knowledge flow model'

The application of the knowledge flow model to the three Algerian small satellite collaborative projects has only been possible at the upper level of the decomposition-integration process (Figure 7-8). No significant activities have been observed at lower levels.

Figure 7-8: Upper level of the decomposition-integration process



Source: Author.

The application of the model reveals that Algerian teams involved in the process slightly improved the architectural knowledge required for the integration of small satellites. Figures 7-3, 7-5 and 7-6 illustrate the increase in terms of architectural knowledge ($KVis_0$). However, component knowledge ($KVel_0$) remains limited in all projects.

This result corroborates responses to questions regarding the knowledge acquired by Algerian teams asked during managerial-level interviews.[3] Indeed, interviewees point to the fact that, unlike with the initial satellites (Alsat-1, and Alsat-2A), Algerian teams locally integrated the two subsequent satellites (Alsat-2B, and Alsat-1B) at CDS/Oran facilities, demonstrating great independence. They emphasise that the integration was carried out under minimal supervision from transferor representatives, a deliberate measure intended to enhance local team confidence.

On the other hand, responses were less categorical when it came to ability to build components locally (acquiring component knowledge). At individual and team level,[4] there was a general consensus that human resources allocated at component level were well below the requirements for building such components. Interviewees consider that only 14% of the required human resources for component development were allocated to projects.[5] Consequently, due to the low number of individuals taking an active part, the absorptive capacity of the acquirer was reduced from the outset.

This deficiency is acknowledged at managerial level.[6] However, no clear alternative is suggested to channel resources towards less scattered participation (i.e. a limited number of individuals scattered over a wide range of components).[7] Similarly, no clear alternative is suggested with regard to the depth of component knowledge targeted.[8] This is reflective of the difficulty of finding the right component/architectural balance across all levels of the technological system's decomposition-integration spectrum.

Another aspect appears to particularly affect component knowledge acquisition. A slight difference is observed in terms of component knowledge acquired in projects conducted with SSTL-UK (i.e. Alsat-1 and Alsat-1B) and on the project with Airbus-France (i.e. Alsat-2). Component knowledge in Alsat-1 and Alsat-1B seems to be slightly higher than in Alsat-2. This can be explained by company size and the business model adopted by the technology transferor.

With respect to Alsat-1 and Alsat-1B, empirical data reveal that the bulk of component development, satellite integration and testing were insourced at SSTL-UK.[9] This high level of vertical integration,[10] which goes a long way towards explaining SSTL's durability, provides an opportunity for transferees in collaborative projects to be in direct contact with component technology, and to increase their knowledge thereby. On the other hand, data collected on the Alsat-2 project highlight that the Airbus approach to building satellites is different.[11] It is a large company which focuses on building integrative knowledge and outsourcing component development.[12] This business model seems to inadvertently steer Algerian participants away from acquiring component knowledge.

With regard to the indigenisation level of the acquired knowledge, data collected reveal[13] that for such a nascent activity (i.e. satellite development in Algeria), it is considered premature to broach questions about local value creation, through for instance establishing a local supply chain. However, some initiatives have been set underway to involve local industry in the manufacturing of some non-core elements of the satellite system.

In the first successful initiative of its kind, the company ECA (Aeronautical Construction Enterprise) in Tafraoui/Oran was involved in the manufacture of some mechanical ground support equipment (MGSE) for Alsat-2 (e.g. transport container, vertical trolley, ballast, metal plate, collar ferrules and mechanical seal).[14] The second attempt was less successful. ECA was involved in the manufacture of three on-board mechanical components (part of the satellite structure) and two MGSE components for Alsat-1B. In this batch, only one (on-board) component was delivered. The rest were either non-compliant with the timescale or non-compliant with space industry quality requirements.[15]

Another local research centre (i.e. the Centre for Development of Advanced Technologies – CDTA/Algiers) was involved in the manufacture of some electrical ground support equipment (EGSE). However, this initiative was also unsuccessful due to non-compliance with the timescale on the part of CDTA.[16]

In spite of such setbacks, interviewees[17] involved in the outsourcing process consider that both ECA and CDTA have the requisite technical expertise. However, these companies need upgrading so as they comply with space industry quality requirements (e.g. specification definition, accuracy, traceability of measurements, test procedures), as well as an appropriate project management system. In this regard, ECA's representatives[18] have raised the need for more visibility vis-à-vis their future relationship with ASAL and the durability of ECA's involvement in the space programme. It is a need for a proper assessment of the risks involved and a cost-benefit analysis.

These concerns extend to the incentives offered and to the broader policy towards local actors and the building of a space-compliant national industry. They relate also to the mechanism used for technology transfer (and technology diffusion) from the Algerian space agency to local industrial actors.

7.1.2 Post-project learning - implementation of the 'experiential learning model'

As mentioned earlier, Algeria's strategy of small satellite technological capability-building takes a two-pronged approach: on the one hand, acquiring technology (or knowledge) from abroad by means of three successive collaborative projects (Alsat-1, Alsat-2 and Alsat-1B); on the other hand, diffusing technology locally and gradually in order to build local capabilities. The experiential learning model presented in chapter 4 (section 4.4) and implemented in this section aims to evaluate the level of local diffusion of acquired knowledge. In other words, it evaluates learning occurring after the projects, within the Algerian space agency and its environment, corresponding to the four learning levels: individual, group, organisation and inter-organisation.

Engineers and scientists directly involved in the development of Alsat-1, Alsat-2, and Alsat-1B, are essentially those who possess the acquired knowledge.[19] This knowledge, which stems from 'learning by doing' and 'learning by searching', is supposedly enriched and converted through interactions (learning by interacting) into group opportunities and is then embedded and amplified in the context of the organisation and inter-organisation.

a. Individual learning

At the individual level, learning is effective when it combines action (learning by doing) and reflection (learning by searching).[20] Individuals involved in satellite development largely agreed (78%) that a 'fair' combination of hands-on and theoretical knowledge was provided for each individual during the lifetime of the projects (Alsat-1, Alsat-2, and Alsat-1B).[21] However, they almost unanimously (98%) deplored the imbalance in their assigned work activities since the conclusion of the projects. Indeed, 92% of them consider that their post-project activities were greatly oriented towards theoretical research without an eye to practical implementation (i.e. engineering aspects). Conversely, 6% consider that their post-project activities were oriented strictly towards engineering and exploitation. Only 2% found an acceptable balance between action and reflection in their activities. The latter are mainly those who interacted with the satellite during its operational phase.

Individuals from Alsat-1, and to a lesser extent from Alsat-2, as well as Alsat-1B did not employ (and still do not employ) the practical knowledge (i.e. development and engineering aspects) acquired during Alsat-1, Alsat-2 and Alsat-1B after these projects had ended. They recognise an erosion in the knowledge previously acquired.

Alsat-1 individuals appear to be the most affected, as their practical experience dates back to 2000-2002. In addition, 36% of the Alsat-1 team gradually left ASAL after the project ending (mainly as a consequence of ‘brain drain’ to Western organisations).[22] This was also reflected in the strong sense of ‘unfinished business’ observed among Alsat-1 individuals.[23] Indeed, as part of the Alsat-1 project, they, working alongside SSTL engineers, built two satellites; one which flew, and a second as a training model, brought back to Algeria after the project. Alsat-1 individuals regret that it was not possible to conduct experiments on it (or to ‘play’ with it) once back.[24] This regret is understandable, as the best way to make learning effective and to accelerate its pace is to make skilful use of ‘playing’ (i.e. learning by playing, see chapter 2, subsection 2.4.5).[25] This also likely reflects the relative risk-averse environment within CDS. It might also reflect individuals’ fear of reprisal should they make mistakes when experimenting or ‘playing’ with objects; to wit, around 49% of satellite team members believe that ASAL is a highly risk-averse organisation.

With regard to the reflective component of learning (learning by searching), formal research and development is thought of as a significant enabler of learning by searching.[26] However, its effectiveness is doubtful in the case under study, as many research projects are not directly linked to small satellite technology.[27] Moreover, those related to small satellite technology do not go beyond the laboratory stage of development in terms of experimentation and simulation.[28] This is also reflected in the absence of any proclivity for patenting within the culture of CDS and even ASAL. No patent has yet been granted as a result of research activity within CDS.[29]

In answering questions about the reasons behind, firstly, the imbalance between research and engineering activities and, secondly, the trend towards too much non-channelled research, interviewees cited several constraints. These relate mainly to: (i) lack of clear objectives, visibility and communication; (ii) lack of equipment and funds; (iii) ill-balanced incentives, as incentives for research activities greatly exceed those of engineering; and (iii) a deep misunderstanding of questions relating to property rights infringement and confidentiality and non-disclosure agreements signed when joining either ASAL or the project teams. These constraints have resulted in poor alignment of individual effort with the objectives of small satellite development. As some constraints directly affect the transformation of individual learning into collective learning, they are discussed further in the following sections.

From the foregoing, it is clear that learning at the individual level is ineffective, as its purpose is not always aligned with organisational goals and the learning cycle is thus not completed. It does not combine action (learning by doing) and reflection (learning by searching). It is also alarming that the bulk of individuals previously involved in collaborative satellite projects are impacted by this ineffectiveness.

Moreover, Kolb[30] explains that combining action with reflection is not always a natural ability and individuals develop particular learning styles throughout their lives. Consequently, an unanswered question in the present study is whether individuals involved in satellite development always maintain the ability to combine action and reflection, acquired during the previous satellite projects, or whether they have subsequently developed an established style towards theoretical (or non-practical) learning, which is difficult to overcome.

b. Group learning

Group learning refers to knowledge held by the group as a whole and not by single individuals. As the rationale of the present evaluation is to trace knowledge flow from its acquisition abroad to its diffusion locally, evaluation of group learning begins by evaluating the activities of the satellite project teams subsequent to project completion. The idea is to determine whether subsequent group knowledge is built on previous experience (i.e. Alsat-1, Alsat-2, and Alsat-1B projects).

- Project team activities subsequent to collaborative project completion

The Alsat-1 team was virtually dismantled following completion of the project.[1] Its members were scattered across various organisational structures (departments and services in CTS and then CDS).[31] They continued to support ASAL's activities, such as specifying and evaluating Alsat-2 and Alsat-1B missions. However, no significant common goal in terms of satellite development (design or engineering) led them to reassemble again. It is problematic to talk about post-Alsat-1 group knowledge, irrespective of the nature of this knowledge (theoretical or practical).

The Alsat-1B team finished building the satellite at the end of 2016, and the present study does not thoroughly examine its activity post-project. However, during the fieldwork conducted in April, May, July, and August of 2016, its members had been assigned new roles and been split between four separate organisational structures (departments).[2] In this period the project was in its final phases, and team members already raised some concerns as to difficulties of interaction because of organisational boundaries. In addition, they had no clear visibility as to their future positions and missions.[32] In this regard, lack of visibility and poor internal communication were recurrent issues raised by the majority of team members, irrespective of the project concerned.[33]

The Alsat-2 team proved to be a special case. It was not easy to evaluate post-Alsat-2 group knowledge because the Alsat-2 project had lasted a long time and

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[1] In addition, 36% of team members who gradually left ASAL after the project ending (mainly as a consequence of 'brain drain' to Western organisations).

[2] 33% of the team were assigned to two research departments (22% to the department of research in space instruments and 11% to the department of space mechanics). 45% were assigned to the department of engineering and 22% to the department of exploitation and operations.

the team had not been completely disbanded. The project started in 2006. The first satellite, Alsat-2A, was built and then launched in 2010. The second, Alsat-2B, was integrated and then launched in September 2016.[34] Consequently, the Alsat-2 team was more or less kept intact over the term of the Alsat-2 project.

However, because of the serious delay (four years) in building integration facilities at Oran/Algeria,[3] the team faced many periods of interruption.[35] During these interruptions, team members were assigned new roles across three separate organisational structures (departments) within CDS. Two of these departments are of a more or less similar nature (engineering and AIT - assembly, integration and test), whilst the third is dedicated to satellite operations and exploitation. Meanwhile, 10% of team members left the group over the long duration of the project.[36] Interruptions of group work, member turnover, and confinement into separate departments led inevitably to degradation of group knowledge previously acquired.[37]

On the other hand, there is general agreement that the most valuable aspect of the Alsat-2 project was its long duration.[38] Indeed, Alsat-2 members spent more than twice as much time in direct contact with the transferor as Alsat-1 and Alsat-1B members.[4] This longer-term exposure to technology likely contributed positively to knowledge acquisition through "socialisation"[5] and "combination"[6], as described by Nonaka.[39] Indeed, on a scale of 1-to-5, Alsat-2 members gave an average rating of 4.33 on the intensity of interaction with their mentors (against 3.18 for Alsat-1 and 3.92 for Alsat-1B). This might well be reflective of the degree of tacit knowledge acquired from their mentors (i.e. socialisation). Likewise, the longer exposure time may have enabled them to participate in authoring important documentation (i.e. combination) pertaining to the project

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[3] As Alsat-2B was integrated into CDS Oran/Algeria

[4] Alsat-2 members spent 42 months at Airbus facilities (on average), whereas Alsat-1 and Alsat-1B members spent 16 and 17 months respectively at SSTL facilities (on average).

[5] "socialisation" refers to the conversion of tacit knowledge held by individual to another tacit knowledge held by another individual (e.g. through on-the-job-training).

[6] "combination" refers to the situation where an individual receives pieces of explicit knowledge from another individual and creates new explicit knowledge from them (e.g. knowledge reconfiguration and recontextualisation).

(e.g. reports, routines, test and quality procedures), which may be useful for future projects. The experience is partially ‘memorised’, as the documents (acquired from abroad or locally generated) are saved in a shared online database.

Alsat-1 and Alsat-1B are both at lower levels of “socialisation” and “combination”. First, because the exposure time of the Algerian teams is shorter. Second, because the SSTL approach to building satellites is different than that of Airbus. SSTL adopts a more FBC[7]-like philosophy, with minimal documentation.[40]

It is noteworthy that the three group memories built up during the projects remained isolated from one another (i.e. no project member had access to any other project’s database).[41] Isolation was justified, *inter alia*, by considerations relating to the technology provider’s intellectual property rights and internal ASAL non-disclosure agreements signed by project members.[42] The same considerations were brought up by interviewees when they were asked whether they have trained or mentored new engineers from ASAL.[43] The misunderstanding of the scope of intellectual property rights appears to inhibit the diffusion of knowledge to local engineers.[44]

It is clear from the above that discontinuities exist, in varying degrees, in the progression of teamwork based on consecutive teams’ experiences formed out of the Alsat-1, Alsat-2 and Alsat-1B projects. The question arises as to whether interrupted teamwork has been offset by countervailing forms of collective work (or group formation).

- Are there any other group activities occurring?

Two types of groups are identified in CDS: firstly, nine (09) thematic groups wherein individuals are gathered according to technological themes; and, secondly, four (04) ‘functional’ groups arrayed according to functional structure.[45] These groups can be represented by reference to a matrix structure

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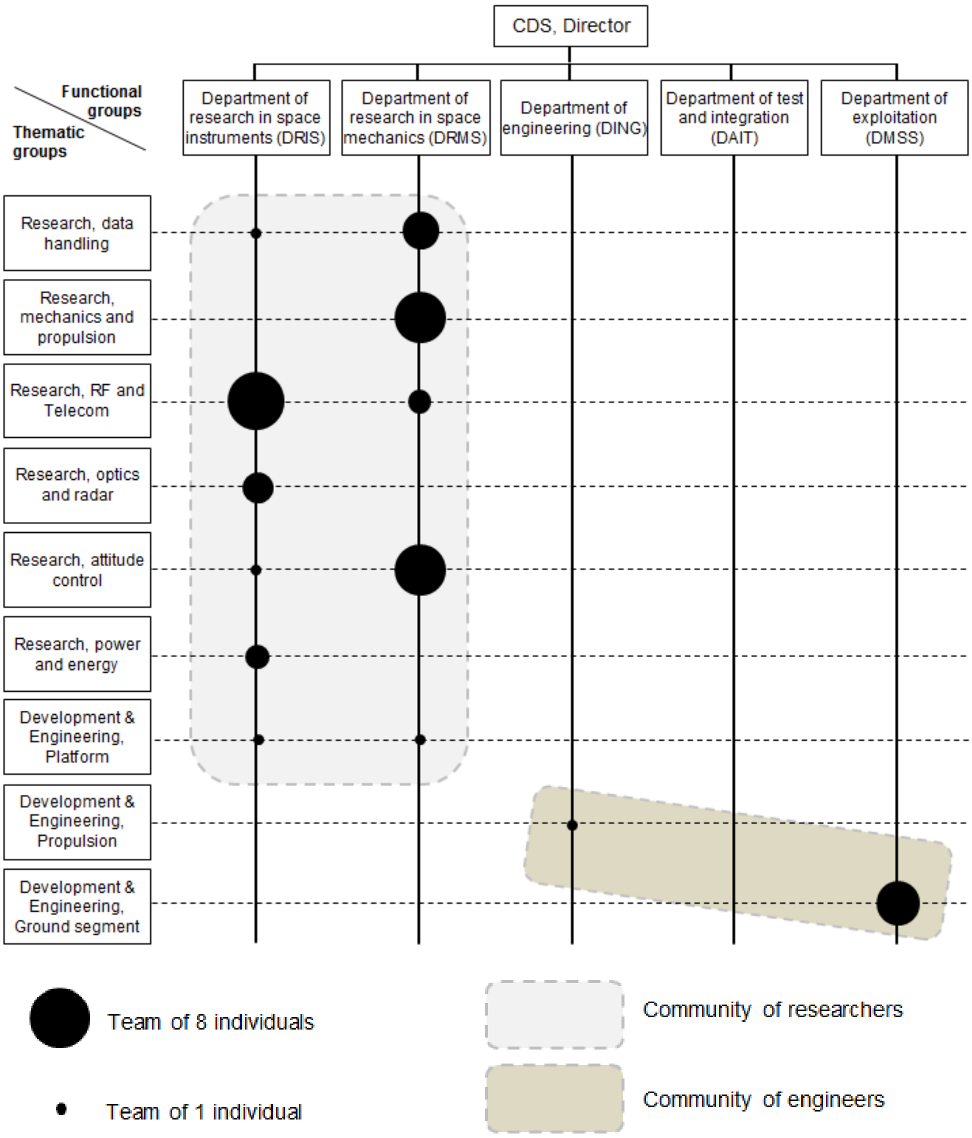
[7] FBC for Faster, Better, Cheaper

(Figure 7-9). Vertical solid lines represent the linear chain of command. Horizontal dotted lines represent the cross-functional relations among the various thematic groups. Black circles denote the number of personnel in each thematic group, including the functional authority.

Figure 7-9: CDS group matrix (functional vs thematic groups)



Source: Author.

Six (06) out of nine (09) thematic groups are dedicated to research (i.e. learning by searching). Each research department hosts three groups (Figure 7-9). According to interviewees, very few cross-functional activities are conducted in terms of research.[46] In addition, group activities are heavily slanted towards research which does not go beyond the laboratory stage (i.e. experimentation and simulation).[47] In addition, group research foci are not clearly aligned with the objective of developing small satellites. Research groups interact (i.e. learning by interacting) with some university-based research teams (e.g. the universities of Oran-USTO, Sidi Belabes and Tlemcen). Two of these groups are instituted as part of the National Research Programme (PNR) overseen by the Algerian Ministry of Higher Education and Scientific Research.[48]

The scarcity of Development and Engineering group activities is noticeable (Figure 7-9). The only engineering activity (i.e. learning by doing) worth mentioning is conducted by the Development and Engineering Ground Segment group.[49] This particular group has been able to, firstly, align its activity with the objective of developing small satellites, and, secondly, to combine development and engineering skills in order to deliver some in-house technical solutions related to the ground segment.[8] Paradoxically, in the small satellite collaborative projects contracted by ASAL, the focus of joint development and integration activities was on the space segments. The ground segments were acquired only for the exploitation of space segments. The proclivity for developing ground solutions after the completion of collaborative projects might relate to the fact that Development and Engineering Ground Segment group is in daily interaction (i.e. learning by interacting) with the satellite operation team because it is hosted by the Department of Operations and Exploitation.[50]

To sum up, interactions between individuals resulted in the creation of nine (09) groups. Group components are virtually mono-departmental (almost every group's members are from the same department). This likely reflects separate

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[8] The group is developing some ground segment equipment (e.g. demodulator, X-band downconverter, flight control calculator, telemetry processing software)

individual efforts (i.e. individual learning) being converted to group level efforts (i.e. group learning) within the same functional department. No significant cross-functional group is identified, particularly between departments in charge of research and those in charge of development and engineering. This bespeaks the fact that groups do not include members with diverse learning styles.[51]

Consequently, learning at research group level is not clearly aligned with the objective of developing small satellites. Moreover, learning is not effective because groups do not combine reflection (i.e. learning by searching) with action (i.e. learning by doing). Learning at Development and Engineering group level is aligned with the objective of developing small satellites. Interaction (i.e. learning by interaction) has facilitated alignment. However, the learning is not effective because the group does not combine reflection (i.e. learning by searching) with action (i.e. learning by doing).

c. Organisational and inter-organisational learning

Organisational learning is a system-level learning where all organisation members, be they individuals or groups, collectively use their capabilities in order to achieve organisational goals. The aim of the present subsection is to evaluate whether learning within CDS is converted to the organisational level. Emphasis is put on whether inter-group activities are intense enough to be considered as organisational.

As mentioned earlier, no common objectives exist between the Alsat-1, Alsat-2 and Alsat-1B project teams. The teams are virtually isolated from each other for reasons that relate, *inter alia*, to the technology provider's intellectual property rights and internal non-disclosure agreements. Instead, CDS management have put in place a new organisational architecture based on nine (09) thematic groups and four (04) functional groups.

Figure 7-9 shows that cross-functional activities are virtually non-existent. This is reflective of a significant dearth of interactions between functional groups (i.e. across organisational boundaries). With respect to thematic group interactions (i.e. vertical interactions in Figure 7-9), the only interactions revealed are those occurring within the Department of Research in Space Mechanics, where groups in charge of data handling, mechanics and propulsion, and attitude control, undertake certain collaborative activities.[52] These findings reveal once again the striking imbalance between research activities (i.e. learning by searching) and engineering activities (i.e. learning by doing) within CDS at inter-group (or organisational) level.

In addition, the findings reveal the ineffectiveness of the cross-functional and cross-thematic structure put in place at CDS (Figure 7-9). Such a matrix structure should fundamentally be built around the immediacy and intensity of interactions between groups (i.e. learning by interacting). However, interactions are missing. The inter-group coordination mission is shared between the CDS director and the internal scientific committee. The CDS director recognises his inability to coordinate effectively inter-group activities in view of the overwhelming weight of administrative and bureaucratic tasks.[53] On the other hand, the scientific committee is not appropriate, as its mission is to steer activities at a relatively 'high' level, whereas no entity is there to handle day-to-day coordination.[54] One of the ideas proposed by an interviewee as a way to foster inter-group interaction is to appoint a manager in charge of technical and scientific coordination.[55] This idea sits in accordance with what is commonly recommended in FBC-philosophy projects; namely, the appointment of a chief scientist or 'principal investigator'.[56]

From a Kolb-cycle perspective,[57] CDS does not diversify its experience as its limited inter-group activity is oriented towards research. In addition, the clear lack of interaction jeopardises CDS's ability to collectively integrate and interpret knowledge acquired from previous experience. Limited and isolated CDS engineering capabilities prevent the translation of knowledge into tangible outcomes. Consequently, CDS is not a learning organisation with regard to developing small satellites.

With respect to inter-organisational learning, CDS has been designated as the lead institution in Algeria charged with developing small satellite capabilities. A network of organisations is supposed to be built around CDS and contribute to the goal of satellite development. However, CDS as a unified and cohesive whole does not exist from a learning perspective, and is thus incapable of addressing learning cycles at the inter-organisational level.

d. 'Too' many missing links for generating systemic learning

Learning is systemic when processes occur at separate levels of aggregation and interrelate with each other. Shared experience is then built over time through dense and continuous interactions. In the case of CDS, there is evidence to suggest that two types of activity trigger off two distinct learning dynamics. The first is satellite collaborative projects with foreign companies. The Alsat-2 and Alsat-1B teams triggered interactions with one local partner regarding engineering issues (i.e. manufacturing mechanical components). These interactions were 'exploitative-exploitative',[9] in the sense of the proposed 'experiential learning model' (Table 7-3). These one-time actions ceased after project completion.[58]

Table 7-3: Dialogue between project groups and the local partner

General combinations	Detailed combinations	Dialogue between
Exploitative-Exploitative	Exploitative action-Exploitative action	Nil
	Exploitative action-Exploitative reflection	Nil
	Exploitative reflection-Exploitative action	Alsat-2 and Alsat-1B groups, who mature the task conceptually (using mature design of the mechanical components) and Local partner ECA, who (regularly) performs practical tasks (regularly manufacturing mechanical components)
	Exploitative reflection-Exploitative reflection	Nil

Source: Author

[9] Corresponding to the dialogue between a learner who (regularly) performs practical tasks (e.g. manufacturing tasks) or conceptually matures the tasks (e.g. mature design) and a learner who (regularly) performs practical tasks (e.g. manufacturing tasks) or conceptually matures the tasks (e.g. mature design)

The second activity was undertaken by CDS outside the collaborative projects. As illustrated in Figure 7-9, two communities of learners are formed. The community of engineers and the community of researchers (be they individuals or groups). Intra-engineers interactions are fledgling. These interactions are exploitative-exploitative, in the sense of the proposed 'experiential learning model' (Table 7-4). However, this community has virtually no interaction with its environment (inside and outside CDS).

Table 7-4: Dialogue within engineering groups

General combinations	Detailed combinations	Dialogue between
Exploitative-Exploitative	Exploitative action-Exploitative action	Individuals within the group (development & engineering ground segment) on manufacturing (or practical implementation) aspects
	Exploitative action-Exploitative reflection	Individuals within the group (development & engineering ground segment) on manufacturing (or practical implementation) aspects and mature concepts (e.g. mature design)
	Exploitative reflection-Exploitative action	Individuals within the group (development & engineering ground segment) on mature concepts (e.g. mature design) and manufacturing (or practical implementation) aspects
	Exploitative reflection-Exploitative reflection	Individuals within the group (development & engineering ground segment) on mature concepts (e.g. mature design)

Source: Author

With respect to the community of researchers, intra-community interactions are emerging. Many research groups are active, but inter-group activities are still poorly developed. The community of researchers also continuously interacts with its external environment by conducting research with other communities of researchers (e.g. universities). Both intra- and inter-community interactions are not necessarily channelled towards small satellite development. They are predominantly 'explorative-explorative',[10] in the sense of the proposed 'experiential learning model' (Tables 7-5 and 7-6).

[10] Corresponding to the dialogue between a learner who tests and explores practical tasks (e.g. laboratory experience) or conceptual ideas (e.g. research), and a learner who tests and explores practical tasks (e.g. laboratory experience) or conceptual ideas (e.g. research)

Table 7-5: Dialogue within research groups

General combinations	Detailed combinations	Dialogue between
Explorative-Explorative	Explorative action-Explorative action	Individuals within research groups (e.g. data handling, mechanics and propulsion, RF and Telecom) on laboratory experiences and simulations
	Explorative action-Explorative reflection	Individuals within research groups (e.g. data handling, mechanics and propulsion, RF and Telecom) on laboratory experiences, simulations and theoretical research
	Explorative reflection –Explorative action	Individuals within research groups (e.g. data handling, mechanics and propulsion, RF and Telecom) on theoretical research and laboratory experiences and simulations
	Explorative reflection-Explorative reflection	Individuals within research groups (e.g. data handling, mechanics and propulsion, RF and Telecom) on theoretical research

Source: Author

Table 7-6: Dialogue of research groups with external communities of researchers

General combinations	Detailed combinations	Dialogue between
Explorative-Explorative	Explorative action-Explorative action	Research groups (e.g. data handling, mechanics and propulsion, RF and Telecom) and groups in universities (e.g. Oran-USTO, Sidi Belabes, Tlemcen) on laboratory experiences and simulations
	Explorative action-Explorative reflection	Research groups (e.g. data handling, mechanics and propulsion, RF and Telecom) and groups in universities (e.g. Oran-USTO, Sidi Belabes, Tlemcen) on laboratory experiences, simulations and theoretical research
	Explorative reflection –Explorative action	Research groups (e.g. data handling, mechanics and propulsion, RF and Telecom) and groups in universities (e.g. Oran-USTO, Sidi Belabes, Tlemcen) on laboratory experiences, simulations and theoretical research
	Explorative reflection-Explorative reflection	Research groups (e.g. data handling, mechanics and propulsion, RF and Telecom) and groups in universities (e.g. Oran-USTO, Sidi Belabes, Tlemcen) on theoretical research

Source: Author

In the development of small satellites in Algeria, it is clear from the above analysis that many links are missing for learning to be systemic. Considerable effort should be made towards linking learners at all levels of aggregation and through diversified combinations.

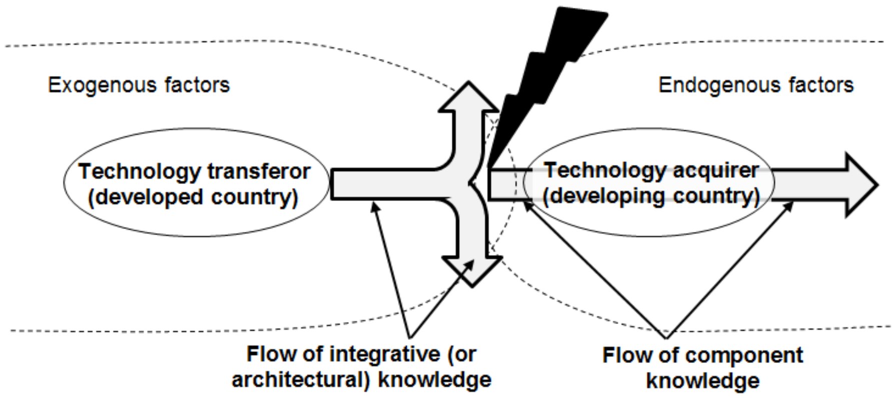
e. Findings from implementation of the 'Experiential learning model'

The application of the experiential learning model to evaluate learning occurring within ASAL, following completion of collaborative projects, reveals a multitude of facts.

CDS acquired an initial knowledge from the satellite collaborative projects (i.e. Alsat-1, Alsat-2, and Alsat-1B). This inceptive knowledge is mainly integrative (or architectural), as detailed earlier in subsection 7.1.1 (knowledge flow model). It is noteworthy that integrative (or architectural) knowledge is organisational in nature.[59] It is held by the organisation as a whole. After project completion, CDS does not exist as an organisational learning entity. The organisational arrangements set up in CDS are ineffective for acquiring and developing integrative (or architectural) knowledge. Learning is oriented towards components. Thematic (i.e. component-centred) activities prevail, whereas cross-thematic (or integrative) activities are non-existent.

This situation can be described as non-alignment between the knowledge flowing from the collaborative projects and the knowledge that CDS attempts to create after completion of the collaborative projects (Figure 7-10). In other words, the integrative learning dynamic, triggered during the collaborative projects, is interrupted and diverted towards component-centred learning.

Figure 7-10: Non-alignment in knowledge flow



Source: Author.

7.2 Extent of locally built technological capability

Evaluation of locally built small satellite technological capability was undertaken in two phases: firstly, identifying these capabilities; secondly, evaluating their levels of complexity (or sophistication). In accordance with the evaluation framework proposed in the present study (chapter 4), micro-, meso-, and macro-level technological capabilities can be evaluated. For each level of analysis, the technological capabilities identified are embodied into physical investment (e.g. equipment, machinery, tools, and physical facilities), human capital (e.g. skills, experience, wisdom), information (e.g. documentation, process specification, procedures, concepts, theories, observations), and management capabilities (e.g. planning, organising, motivating, incentivising, commitment).

These capabilities interact. Physical investment is developed, installed and operated by human capital. Human capital is guided by information which is maintained and updated by human capital. Physical investment, human capital and information are brought together through management capabilities. Technological capabilities are then characterised in terms of degrees (i.e. basic/simple, intermediate, or advanced) of sophistication (or complexity).

Satellite development is usually conducted though phases. These phases are gathered in three broad categories: specification & design, engineering & AIT (assembly, integration and testing), and operations & exploitation. Data collected from interviews and *in situ* observations reveal that in terms of satellite operations & exploitation, ASAL (or CDS) has progressively built the physical investment, human capital, information, and the required management capabilities to enable local engineers to operate and exploit the satellite independently and effectively.[60]

By contrast, further data reveal the paradoxical status of these capabilities when it comes to specifying and designing small satellites. Algerian engineers have steadily built a slew of capabilities required for satellite system specification.[61] More than two thirds of engineers interviewed contend that these capabilities are basic. Additionally, there is an almost complete consensus on the non-existence of satellite design capabilities (e.g. physical resources, human capital, information, and management).[62] Indeed, no Algerian engineers took part in the design phase of the collaborative projects (i.e. Alsat-1, Alsat-2 and Alsat-1B).

They generally worked on mature technologies inherited from previous approved designs. Moreover, no local effort has been made to advance this aspect after completion of the collaborative projects.

The paradox is that ASAL's emphasis during the collaborative projects was on developing integrative (or architectural) knowledge (subsection 7.1.1). Architectural knowledge originates from knowledge on how the product is designed.[63] This means that building architectural knowledge is largely explained by the birth phase of this knowledge, which is the design phase, but ASAL virtually overlooked these capabilities.

With respect to engineering & AIT activities, the bulk of physical investment has been dedicated to AIT activities. Relatively 'heavy' AIT facilities have been installed in CDS (i.e. AIT clean room and thermal chambers) along with certain accompanying equipment.[64] Other 'heavy' AIT facilities have not been installed (e.g. electromagnetic and acoustic compatibility) and associated activities are supposed to be outsourced abroad. By contrast, a significant amount of 'light' equipment (e.g. tools and small electronic equipment) is missing. This equipment is used in both engineering and AIT activities. It turned out that despite the fact that this equipment is 'simple' and 'light', it has an impact on the whole of the engineering and AIT activities. This is reflective of the paradoxical situation surrounding the physical investment relating to engineering & AIT activities. The organisation achieved the more challenging primary investment but had difficulties in achieving a complementary and, indeed, 'simpler' investment. This handicap has negatively affected the development of engineering activities, as explained in subsection 7.1.2.

Issues relating to information capabilities (e.g. documentation) have been addressed above (subsection 7.1.2). As has been discussed, separate project memories were built but remained isolated from one another. Consequently, information capabilities were partially built, but they have not reached the organisational level. What is evident from the fieldwork is that building a dynamic, interactive organisational memory dedicated to satellite technology is not a priority.[65]

Where human capital in engineering & AIT activities is concerned, CDS suffers an imbalance in its human resources. Approximately 80% of resources are earmarked for research and only 20% for engineering.[66] There is an increasing awareness about this issue and the need to 'reverse' the situation.[67] Several actions (i.e. recruitment and training) have been implemented with the aim of bolstering human engineering resources; however, they have foundered on the issue of incentives. CDS personnel generally lean towards a research career, as the incentives of research greatly exceed those of engineering. A senior researcher's salary can be three times higher than the salary of an engineer (with the same number of years' service).[68] This serious imbalance arises out of a more general imbalance relating to the national public sector. Researchers on the government payroll have a more rewarding legal status (i.e. career profile and remuneration package) as compared to engineers of the same ilk. CDS researchers greatly prize this status. For instance, 68% of engineers who took part in the collaborative projects are now either a PhD-holder or pursuing PhD studies, with the intention of engaging in a research career afterwards.[69] Interviewees at high-level management confirmed that initiatives are underway to create an appropriate status for engineers.[70]

Faced with this multitude of deficiencies in engineering activities, interviewees in mid- and high-level management demonstrated awareness that bringing in other Algerian engineering organisations (by developing a local supply chain) could be a way to overcome obstacles.[71] They consider that it is difficult to identify organisations in the local industrial environment having capabilities that are compliant with satellite industry requirements. Consequently, any action should be preceded by a thorough audit of this environment.[11]

[11] It is worth noting that the company (ECA) which was involved in the manufacture of mechanical components for Alsat-2 and Alsat-1B was identified through a limited audit undertaken by ASAL in 2008.

Interviewees argue that there is no clear and explicit strategy towards achieving such objectives. Reasons given often refer to a country-specific non-conducive environment (e.g. bureaucracy, procurement regulation, and cumbersome procedures). Interviewees also recognise that current managerial and organisational capabilities in ASAL and CDS are not comparable with those attained in the realms of physical investment, human resources and information handling.

This highlights the centrality of building internal managerial capabilities once again. Indeed, physical investment, human capital and information handling are brought together through management capabilities. The country-specific non-conducive environment (discussed in chapter 6) should not distract ASAL from taking a critical look at its internal managerial capabilities. Indeed, building internal managerial capability offers increased flexibility in managing the challenging external environment.[72]

7.2.1 Centrality of management capabilities

The evaluation of management capabilities is conducted by comparing the management practices of ASAL and CDS with those acknowledged to be the best available management practices in small satellite and complex system development. Because the development of such technological systems hinges largely on team performance (chapter 3, section 3.5), the management practices examined below are twofold: (i) team-level; and (ii) organisational-level management practices. In small satellite technology, the organisation is expected to provide the appropriate environment; however, the team leads the development.[73] The twin challenge lies in confidence building at the organisation-team interface that then leads to team empowerment.

As noted earlier (subsection 7.1.2), CDS has considerable difficulties putting in place cross-functional teams that can address multiple small satellite requirements. It is therefore difficult to tackle empowerment at team level. For this reason, the proposed evaluation looks at empowerment at lower levels of management. This should reflect empowerment practices in CDS and ASAL.

The starting point for the evaluation is the paradoxical case highlighted earlier concerning physical investment in engineering & AIT activities. CDS/ASAL demonstrate relative success in realising primary (or 'heavy') investments, whereas they are able to show only limited results in terms of simple (or 'light') investment. According to interviewees[74] and field observation, primary investments were relatively successful because particular attention was paid to them by upper-level management. By contrast, 'simpler' investments, which are generally left to lower levels of management, suffer from many deficiencies in implementation. This rather suggests that empowerment of lower levels of management is limited.

Contrary to recommendations for empowerment of teams and lower levels of management, ASAL is a highly centralised organisation when it comes to managing small satellite development. Despite the fact that CDS is located in Oran and is the host organisation for this activity, ASAL, the parent organisation, located in Algiers (about 400 km from Oran), still overmanages and micromanages the ongoing CDS collaborative projects. This situation could have been justified 10 or 15 years ago, at the beginning of Algeria's satellite programme, when 'decentralised' resources were missing. However, it can no longer be justified, as the required resources are now available within CDS, and, paradoxically, the entity which manages these projects in the parent organisation (i.e. ASAL) itself lacks the appropriate resources.[75]

According to interviewees, there is a need to build mutual confidence across ASAL-CDS prior to addressing CDS-team relationships.[76] This situation is further complicated by a general lack of clear objectives, visibility and communication between CDS and ASAL.[77] The situation is replicated within CDS, where nearly all interviewees (96%) deplore the confusion and blurriness surrounding their activities.[78] As a consequence, their commitment and motivation to engage productively in satellite development has decreased.[12]

ASAL's emphasis on primary and 'heavy' investment to the detriment of simple and 'light' investment mirrors its failure to empower lower levels of management. Moreover, it might be grounded in the misconception that 'heavy' investment is more important than 'light' investment. This misconception can potentially have dire consequences for the whole satellite programme. It is necessary to recall that traditionally in small satellite projects, modest additional resources (or investments) improve performance significantly, whereas significant additional resources impact performance only modestly.[79]

This misconception was revealed during the fieldwork as a bifurcation of opinions on the question of how CDS/ASAL should build satellites.[13] There are proponents of the SSTL way of building satellites, who are in favour of an FBC-like philosophy (i.e. limited resources, minimal documentation, small teams, extensive use of commercial off-the-shelf (COTS) components and high vertical integration). On the other hand, proponents of the Airbus way rely more on 'heavy' investment (i.e. bespoke solutions, extensive documentation, large teams and a large network of subcontractors).

To prevent further confusion, greater clarity is needed regarding ASAL's strategy for building satellites, and, over and above that, clarity regarding the goals of satellite development. One set of strategies are usually leveraged when the prevailing goal is 'technology application'; they aim at fostering downstream activities through, for instance, promoting satellite image utilisation. Other strategies are adopted when the prevailing goal is 'technological learning'; for example, fostering design, manufacture and integration of satellite systems (wherein learning how to build satellites is a priority).

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[12] On a scale of 1-to-5, the members of satellite projects interviewed gave an average rating of 3.93 for their motivation during the fieldwork (i.e. after the projects), as against 4.81 before engaging in the projects.

[13] 70% of interviewees are of the view that ASAL should adopt the SSTL way of building satellites, whereas 30% prefer the Airbus way.

The confusion around high-level management goals is evident from Table 7-7. One interviewee at this level reckoned that the priority when making use of successive collaborative projects was technology application.[80] Another felt that the priority was technological learning.[81] Two of the interviewees[82] could not identify a priority and five[83] considered that both goals were being pursued. However, the bulk of the interviewees (seven out of nine) pointed out that goal priorities were not made explicit.

Table 7-7: Collaborative project goals

collaborative project goal priority	Number of interviewees (high-level management)
Technology application	1/9 (11%)
Technology learning	1/9 (11%)
Technology application and technology learning	5/9 (56%)
Not known	2/9 (22%)

Source: Author

The goal confusion has resulted in confusion as to which risk management approach to adopt. Indeed, when downstream activities or technology application are predominant, a highly risk-averse attitude is generally observed, reflecting the organisation's commitment to end-users (e.g. the absolute need to deliver images to users). On the other hand, when technological learning is preferred, higher risk is generally accepted as individuals are still building capabilities and skills. When both are promoted, it is difficult to convey clear guidelines to lower management levels, researchers and engineers with regard to the definition of risk margins. This absence of clarity is an inhibiting factor, since 49% of team members interviewed believe that ASAL is a highly risk-averse organisation where risk taking is not rewarded.[84]

Other management deficiencies were also identified. Indeed, it is recognised in small satellite projects that organisational responsiveness to lower levels of management and to project teams should be good enough to deliver resources whenever needed, rather than loading them with extra-resources. This is facilitated by an *a priori* building of a reservoir of resources.[85] Data collected on the critical aspect of human resources reveal the poor performance of ASAL and CDS in spite of their accumulated experience. For instance, members of the Alsat-1 project were informed of their selection only three weeks (on average) before the project kick-off. Alsat-2 members were informed three months before, whereas Alsat-1B members were informed two months before. Such durations are deemed insufficient for appropriate preparation.[86]

Data collected reveal a severe lack of project management training. All interviewees involved in project management tasks state that they have had little or no formal training in management tools (e.g. scheduling and budgeting), and had learnt 'on-the-job'.[87] Similar findings hold regarding communication skills and communication tools. The interactional deficiencies mentioned in subsection 7.1.2 result partly from communication shortfalls.

Moreover, a severe lack of 'best practice' awareness is revealed with regard to small satellite or complex technology management, such as: (i) the separation between project management tasks and system engineering tasks; (ii) the need to formally and explicitly manage individuals and groups who hold knowledge (particularly tacit knowledge) by pinpointing them and by attributing value to their work; (iii) the need to put in place learning routines; (iv) the need to implement a quality assurance approach that relaxes or eliminates bureaucratic procedures.[88]

Despite the many challenges faced by CDS and ASAL due to their severe lack of management skills and capabilities, no clear strategies seem to have been adopted to address these issues.[89] This situation reflects the chronic lack of awareness of the preeminent role of management in developing satellite capabilities. Despite the significance of ASAL's investment and the relative achievements, efforts remain fragmented and non-channelled.

To sum up, the evaluation reveals a significant number of paradoxical situations. For instance, the acquisition of integrative (or architectural) knowledge and the overlooking of knowledge that relates to design, upon which integrative knowledge is in turn developed. Realising primary and 'heavy' investments and failing to realise complementary and 'simpler' investments. Over-investing in research capabilities and under-investing in engineering and development capabilities.[14] These fragmented efforts led ASAL to build a heterogeneous set of capabilities. These non-systemic capabilities have prevented ASAL from going beyond the simple (basic) use of technology, realising neither development (i.e. intermediate level) nor innovation (i.e. advanced level) activities.

The above findings affirm the sagacity of Drucker's argument that management creates capabilities and that capabilities are the result of management. These findings particularly recall his famous quote, "There are no 'underdeveloped countries'. There are only 'undermanaged' ones".[90]

7.3 Evaluation at the nexus between transferor and transferee

The previous section evaluated locally built small satellite technological capabilities. It addressed factors which are endogenous to ASAL's local context. The present section complements the previous by siting the evaluation at the transferor-transferee interface – applying metrics involving factors that are exogenous to the local context. Metrics are examined at three levels of analysis, micro, meso and macro.

Transferred technology is examined from different technological components: physical investment, human capital, information handling, and management capabilities. As mentioned previously (section 7.2), ASAL has imported a substantial number of physical components and units of equipment from abroad, ranging from basic, 'light' and micro-level equipment to sophisticated, 'heavy' and macro-level equipment. As small satellite technology is usually readily accessible on the international market, no noticeable restrictions were

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[14] In contradiction to the sequence 'engineering, development, and research' which should be used by developing countries when building technological capabilities. Kim, L., 1997. Imitation to Innovation: The Dynamics of Korea's Technological Learning. Harvard Business School Press, p.90.

faced by ASAL regarding its transfer to Algeria. Even if the sale of certain items is subject to restrictive regimes,[15] alternatives are generally available in the marketplace.[91]

Data collected reveal that information transferred from abroad (i.e. documentation and procedures) is either limited (basic)[92] or specific to the satellite system developed. It pertains, first of all, to documentation required for the exploitation of the system. Other documentation that essentially relates to test procedures and results for particular systems and subsystems was also transferred. The latter have a bearing on system integration. Beyond the immediate system and specific context, this documentation is not of great value.[93] Participants in the satellite projects insist on the need for producing local documentation tied in to a locally developed system.[94] However, they recognise that transferred documentation can inspire or guide the production of locally generated documentation.

Unlike physical investment, and, to a lesser extent information (e.g. documentation), human capital and management capabilities cannot easily be transferred, as they are heavily dependent on indigenous considerations. Despite the centrality of management capabilities, ASAL has not parlayed collaborative projects in support of local management capability-building efforts. As outlined above, interviewees involved in project management tasks state that they had no formal management training on satellite projects.[95]

As to human capital, ASAL's engineers have had the opportunity to acquire academic and hands-on knowledge from abroad. Little was acquired in the way of satellite design, since foreign companies are very protective of this knowledge due to its paramount importance to their survivability. Moreover, ASAL and CDS interviewees contend that transferors adopted a variety of stances when conveying technology.[96] From a flexible stance regarding transfer of technology that has been exploited up to its limits, and could therefore be

[15] such as ITAR (International Traffic in Arms Regulations) and EAR (Export Administration Regulations).

transferred without risk,[16] to a rigid stance when it came to transferring new and advanced technology – by limiting the extent of training provided.[17] For the latter, implicit restrictions were set out, for instance, through limiting the number of Algerian participants receiving training on particular subsystems, and through shortening their exposure time to particular technologies.

According to ASAL interviewees, different transferor stances, which are a function of the variety of technologies used, each with a specific degree of maturity, mean that no one-size-fits-all solution can be adopted to acquire technology, and there is a need to be more selective when targeting technologies for acquisition.[97] The interviewees did not indicate what selection should be made (e.g. which technology or subsystem ought to be targeted). On the other hand, they emphasise that restrictions and varying degrees of transferor versatility fully justify the utility of the local learning effort in leveraging the transferred asset.[98] However, the interviewees did not indicate where the focus needed to be in terms of local engineering, development and research efforts to assist maximally in acquiring the variety of technologies used.[99] In other words, data collected reveal ASAL's confusion in formulating a learning strategy for acquiring technology which is composed of 'sub-technologies' at various degrees of maturity. The same confusion has been identified by transferor representatives.[100]

7.3.1 Transferor-transferee mutual understanding

From the foregoing, it is clear that transferor-transferee mutual understanding primarily hinges on the capacity of the two parties to identify a shared view of 'learning' during projects, based on mutual interests. However, in the context of technology transfer from developed to developing countries, the transferor's motives are economic, whereas the transferee's motives are primarily non-economic. The latter aim to acquire new knowledge for building local

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[16] 53.13% of interviewees believe that technology conveyed has been exploited up to its limits and can be transferred without any risk.
[17] 65.62% of interviewees believe that the training provided was not deep enough when technology is advanced.

capabilities. Consequently, another fundamental question needs to be posed during evaluation: to what extent is knowledge transfer affected by non-alignment of objectives?

Transferor-transferee exchanges occur predominantly during the lifetime of the project. The proposed approach is thus to look at the strategic objective of ‘learning’ during the project – through the joint management mechanism adopted by both ASAL and foreign companies. The management mechanism is “fostered around project goals and paced by the project life cycle”. [101] The project cycle V model (chapter 3, section 3.5) is then used to frame the evaluation of the mutual understanding of ‘learning’ from the perspective of both the transferor and transferee.

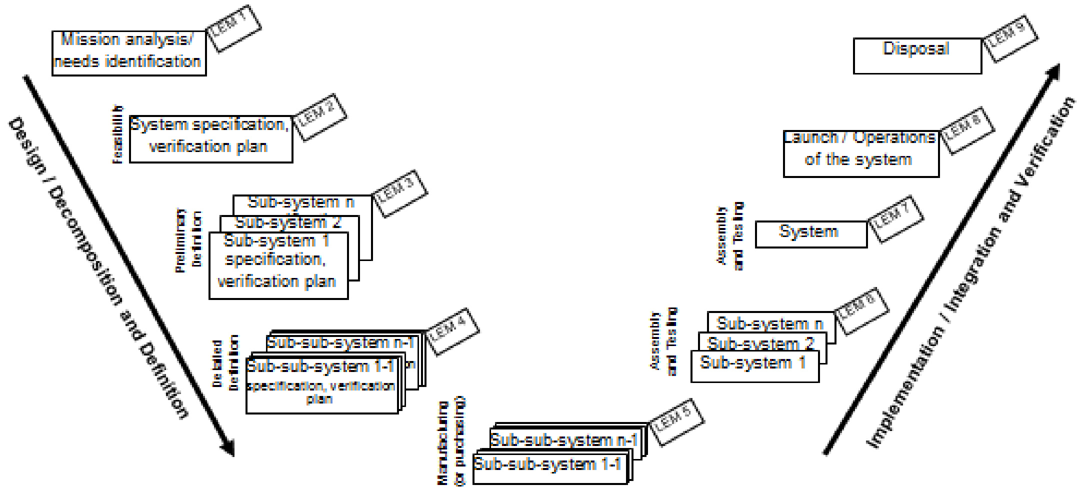
Traditionally, the project cycle captures three congruent aspects of the project; namely, the business, budget, and technical aspects. However, it should not be used as a generic tool. It should be customised (or tailored) according to the strategic objectives of the project and the tactical approaches adopted for achieving those objectives.[102] As the strategic objective under evaluation in the present study is ‘learning’, the V model is tailored accordingly.

The first step of tailoring is to select the appropriate period that is relevant for the ‘learning’ objective. The traditional phases of satellite projects are used for this purpose (Figure 7-11): mission analysis/needs identification, feasibility, preliminary definition, detailed definition, manufacturing (or procurement), assembly and testing, launch and operation of the system, and disposal. [103]

The second step in tailoring is to mark the decision gates (or milestones) and the associated phases that are relevant for ‘learning’ (i.e. LEM for Learning Evaluation Milestones in Figure 7-11).

The third step is to identify project deliverables and associated metrics that must evidence learning at the end of each phase. The final step is to identify tasks required to produce the deliverables.

Figure 7-11: Project cycle tailored according to 'learning' objectives



Source: Author.

Learning Evaluation Milestones (LEM) are interim milestones wherein transfer of knowledge should be evaluated by the transferee. For instance, in LEM 1 (Figure 7-11), the emphasis is on evaluating learning to conduct a mission analysis, identify needs, and translate them into a technological system. In LEM 2 and LEM 3, the emphasis is on metrics measuring integrative knowledge (e.g. system engineering function, skills, software, equipment, facilities, documentation) and component knowledge (e.g. the subsystem involved, skills, software, equipment, facilities, documentation) required for designing the whole system.[104] At this level, capabilities of the local acquirer should be evaluated and this yields an evaluation of local value. In LEM 3 and LEM 4, the emphasis is on designing subsystems. With regards to local value, actors involved are those at the lower level in the supply chain. The same rationale applies at each of the Learning Evaluation Milestones in both legs of the V model (Figure 7-11): design/decomposition and definition, as well as implementation/integration and verification.

During the fieldwork, emphasis was put on whether the strategic objective of 'learning' was explicitly recognised all throughout the project phases. This should be reflected in whether each phase has an explicit learning objective, whether the metrics for evaluating learning are known, whether deliverables that evidence learning are understood and tasks required for producing the deliverables are explicitly defined. Table 7-8 summarises degree of explicitness (i.e. explicit, moderately explicit, lowly explicit, non-explicit) revealed by participants in the collaborative projects.[105]

Algerian engineers did not participate in the project design phase and instead mainly worked on technologies inherited from previous approved designs.[106] Consequently, learning as part of the design/decomposition and definition phases (i.e. left leg of the V model in Figure 7-11) is overlooked. An exception has been made for the first phase (i.e. mission analysis/needs identification in Table 7-8) where learning is explicit or moderately explicit as an objective.

Learning in the final phase (disposal) is explicit. This is reflective of the importance given by ASAL to building capabilities that enable local engineers to independently operate satellites.[107] On the other hand, learning aspects in the prior phases (i.e. manufacturing (or procurement), assembly and testing, and launch and operations) are either non-explicit or not explicit enough (i.e. lowly or moderately explicit). For instance, during manufacturing, assembly and testing, work packages were used to guide the actions to be undertaken by Algerian engineers during the projects. These work packages, which are supposed to trace the road map for learning, were: (i) sometimes not understood; (ii) deemed very general and not detailed enough; or (iii) too narrowly oriented towards rather specialised aspects; or (iv) not properly balanced (i.e. fostering neither theoretical nor practical aspects); or (v) disregarding of the prior knowledge of learners; or even (vi) dependent upon the transferor's willingness or availability.[108]

Table 7-8: Learning objective during collaborative projects

Project phases	Explicitness of learning objective	Explicitness of learning evaluation metrics	Explicitness of deliverables that evidence learning	Explicitness of tasks required for producing deliverables
Mission analysis/needs identification	Explicit	Moderately explicit	Moderately explicit	Moderately explicit
Feasibility	N/A	N/A	N/A	N/A
Preliminary Definition	N/A	N/A	N/A	N/A
Detailed Definition	N/A	N/A	N/A	N/A
Manufacturing (or procurement)	Lowly explicit	Non-explicit	Non-explicit	Non-explicit
Assembly and Testing	Lowly explicit	Moderately explicit	Moderately explicit	Moderately explicit
Launch and operations	Lowly explicit	Non-explicit	Non-explicit	Non-explicit
Disposal	Explicit	Explicit	Explicit	Explicit

N/A: Mentioned when learning is completely not considered

Source: Author.

In addition, interviews with higher levels of management[109] and with foreign company representatives revealed that less attention was paid to learning as an objective at interim milestones. According to foreign company representatives, the disparity in the prior knowledge of Algerian engineers made it difficult to thoroughly devise and evaluate a homogeneous and detailed learning programme.[110]

Consequently, at the interim milestones, learning strategy and tactics were rarely examined, and risks and opportunities related to learning were rarely assessed. Additionally, learning objectives and schedules were not often re-examined or adjusted. Learning via networking between individuals, groups and organisations was also not often discussed or facilitated.

The author reviewed the minutes of meetings relating to milestones in the Alsat-2 and Alsat-1B projects,[18] and attended three meetings of the Alsat-1B project.[19] The author noted that learning as an objective was rarely examined. The bulk of discussions or actions were centred around technical aspects and scheduling.

According to interviewees,[111] a detailed project learning plan was insufficiently addressed. The reason given is that it would be a difficult task given the wide range of uncertainties and changes faced. It is apt to highlight that the Algerian attitude towards a detailed learning plan runs contrary to the adage: ‘The harder it is to plan, the more you need to’.

Evidence gathered, and represented by the shaded areas in Table 7-8, suggests that ASAL assessed learning more through a summative perspective, with an emphasis on final and tangible outcomes and results. In other words, the learning processes within the project were addressed as a black box, where the emphasis is on outcomes. However, learning in such projects is often a long and laborious process, and rarely produces swift, tangible outputs. Therefore, Algeria’s small satellite projects do not easily lend themselves to traditional evaluation based on the ‘instrumental’ use of outcomes. Such evaluation approaches cause distorted perceptions of the transfer process, preventing deep understanding and the adoption of appropriate measures for enhancing transfer.

Even though learning should have been the strategic objective of ASAL, it is clear from the foregoing that it was not the driving force behind the projects. It is likely that other aspects (i.e. technical, cost-related and scheduling) prevailed. These other aspects are reflecting the prevalence of foreign partner’s strategic objectives. Consequently, the initial non-alignment of objectives led to the

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[18] Examples: Minutes of Preliminary Design Review-PDR, Critical Design Review-CDR of Alsat-2 and Alsat-1B.

[19] Preliminary Design Review-PDR held in SSTL/UK on 25-28 November 2014.
Module Readiness Review-MRR held in SSTL/UK on 26-31 November 2015.
In-Orbit Commissioning Review 17-20 July 2017.

adoption of management tools (i.e. project cycle) that serve the interests of foreign companies more than those of ASAL. This often resulted in an uneasy, conflicting, relationship between ASAL and its foreign partners.[112]

The prevalence of non-learning objectives goes a long way towards explaining the ambivalent management perspective within CDS and ASAL on learning performance. Interviewees from all management levels expressed a sense of frustration and dissatisfaction over this inability to overcome learning barriers after three attempts (i.e. Alsat-1, Alsat-2, and Alsat-1B).[113] They argued that some of the reasons are domestic, whereas others relate to the transferor's lack of willingness to fully transfer technology. No clear approach was observed during the fieldwork as to how ASAL should address learning when objectives are not aligned.

7.3.2 Other factors impacting on transferor-transferee linkages

As the evidence suggests, management tools used by ASAL during the projects do not prioritise transferee learning objectives. This prompts questions about the appropriateness of ASAL's other management practices during the projects, and whether they foster the building of sound linkages between ASAL and foreign companies.

Mutual understanding between ASAL and foreign companies is also a matter of negotiation balance. This largely hinges on the prior knowledge of ASAL, its international experience and the market (whether it is a buyer or a supplier market).

The analysis of the effects of transferee absorptive capacity on knowledge flow (subsection 7.1.1) shows that ASAL increased its prior technological knowledge over time and over the projects' timeline. ASAL's international experience increased after three collaborative projects. ASAL's interviewees recalled differences in ways of building satellites between SSTL and Airbus. They pointed out that the diversification of foreign partners brought diversity of international experience.[114] These interviewees highlighted, for instance, the importance of the human dimension when it comes to SSTL (i.e. a small company), and the importance of administrative procedures when it comes to Airbus (i.e. a large company).

In addition, ASAL's interviewees stressed that the diversification of international experience offered broader perspectives and greater bargaining power in a market which is dominated by a few suppliers.[115] However, they expressed concerns about the future, as large companies such as Airbus perceive a threat in the emergence of smaller companies, such as SSTL. To address this threat, Airbus, for instance, acquired SSTL in 2008. The effect of this acquisition has been felt by ASAL. ASAL's interviewees pointed out the relative ease with which ASAL used to collaborate with SSTL during the Alsat-1 project when SSTL was an independent company. They explained that this ease in collaboration was no longer present to the same extent during the Alsat-1B project, as SSTL had become part of Airbus. Collaboration has become 'heavier' and dominated by administrative procedures and contractual clauses.[116] Moreover, ASAL's interviewees expressed concerns about the consequences of this trend in terms of further limiting their bargaining power and rendering relationships with suppliers difficult.[117] No clear strategy was observed during the fieldwork as to how ASAL should address such a trend in the international market.[118]

For a better understanding of the relationship between ASAL and foreign companies, the former should enhance management practices to overcome cultural barriers. Given the complexity of the cultural construct, the present evaluation has only looked at a subset of factors that influence mutual 'cultural' understanding. For instance, in the projects conducted with SSTL-UK (i.e. Alsat-1 and Alsat-1B), English as the working language made communication difficult between the Algerian engineers and their counterparts from SSTL. Not to mention the difficulties in relationships caused by the idiosyncrasies of personality type.[119] Project managers, even foreign company representatives, expressed concern about the selection process for the engineers and stressed the need to improve it. In addition to appropriate language training, ASAL's project managers suggested the need to introduce psycho-technical tests for team members.

7.3.3 Appropriateness of the technology transfer mechanism

ASAL used collaborative projects as a mechanism for learning how to develop satellites. The mechanism offered ASAL's engineers a combination of theoretical and hands-on technical training. Projects were led by foreign companies. Algerians did not have effective project control. Consequently, the central aspect in the management of satellite development was under-explored by Algerian teams. This is reflected through the way risk was managed. Because contractual responsibility lies primarily with the supplier, the common practice of ASAL representatives was to transfer risk to foreign companies. ASAL was involved, guided some decisions, provided inputs, but was not primarily responsible for the final product.[20]

As mentioned above, satellites were built using technologies inherited from previous approved designs. The satellite design aspect was not covered by this transfer mechanism,[120] and Algerians could not develop technical and managerial skills related to design. Yet the primary significance of the design phase is in acquiring long-lasting architectural knowledge and gaining creative independence (see section 7.2).

As explained above (section 7.3), learning turns out not to have been the main thrust of the transfer mechanism. As the projects were led by foreign companies, aspects which are more relevant to foreign companies (i.e. technical, cost-related and scheduling) prevailed. In addition, the mechanism used did not allow proper monitoring and assessment of learning due to the management tools adopted. Difficulties increased as the bulk of the projects were conducted at supplier facilities (i.e. UK or France), far away from ASAL management.

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[20] Neither project contracts nor project minutes mentioned a clear responsibility of ASAL in satellite development.

This distance isolated the Algerian participants technologically from their local environment. Project emphasis was placed on these participants only. Projects did not involve other local actors in Algeria. Consequently, the learning effort fostered during the projects (known also as discontinuous learning under crisis)[121] ceased at the end of the projects. The mechanism used lacks connectivity with post-crisis learning.

To sum up, the previous and the present chapters have respectively analysed the context and the planning as well as implementation of the small satellite capability-building programme in Algeria. The analysis has revealed mixed results for this programme in all its aspects (i.e. embedment in the Algerian context, planning and implementation). These results, which affect a wide range of issues, are presented in the following chapter through a set of conclusions and associated recommendations.

References and Notes

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[3] Interview: ID-41 (April 2016)

Interview: ID-36 (April 2016)

Interview: ID-39 (July 2016)

Interview: ID-19 (July 2016)

Interview: ID-48 (August 2016)

[4] Interviews conducted with members of the small satellite project teams (April, May, July, August 2016).

[5] Ibid.

[6] Interview: ID-41 (April 2016)

Interview: ID-39 (July 2016)

Interview: ID-48 (August 2016)

[7] Ibid

Primary observation of the author (Alsat-1B meetings)

Secondary observation of the author (visit of ASAL and CDS)

Secondary observation of the author (visit of ASAL and CDS)

[8] Ibid

[9] Interview: ID-1 (April 2016)

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[11] Interview: ID-39 (July 2016)

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[12] Petroni, G., Santini, S., 2012. Innovation and change? The evolution of Europe's small satellite manufacturers. Space Policy 28, 25-32.

[13] Interview: ID-41 (April 2016)

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[14] Interview: ID-44 (April 2016)

Interview: ID-41 (April 2016)

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[15] Ibid.

[16] Interview: ID-39 (July 2016)

[17] Interview: ID-44 (April 2016)

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Interview: ID-41 (April 2016)

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Interviews conducted with members of the small satellite project teams (April, May, July, August 2016).

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Chapter 8: Conclusions and Recommendations

8.1 Summary

The purpose of this study has been to evaluate the small satellite capability-building programme in Algeria. In the context of developing countries, technological development usually involves two categories of factors: those exogenous and those endogenous to the host country. Exogenous factors are those factors that mediate the transfer of technology from abroad. Such factors are grouped under the body of knowledge called 'technology transfer'. Endogenous factors, on the other hand, are those impacting local efforts to acquire the transferred technology, and indigenise it. These factors are grouped under the body of knowledge called 'technological capability-building'.

The technology transfer or technological capability-building debate in developing countries is traditionally dominated by market perspectives and largely informed by mono-dimensional economic approaches. Indeed, the debate builds on cases where transferor economic (i.e. business oriented) motives are in alignment with transferee economic motives.

This market perspective is deemed inappropriate for the purposes of the present study, which investigates technology transfer to Algeria of small satellite technology used in Earth observation satellites. Internationally this technology generates only modest profit, and its market is not yet well developed. Therefore, its exploitation cannot easily be justified in economic terms. By investing in small satellite technology, the Algerian Space Agency, unlike its foreign partners (i.e. technology transferors), is driven by developmental and non-economic goals.

In the current era, development, including technological development, is a knowledge-centred process. Transferring and indigenising technology is tantamount to acquiring and diffusing knowledge. In simple terms, it is a learning process. Accordingly, a knowledge-oriented stance has been adopted, placing the evaluation of technological learning at the heart of the present thesis. The learning perspective has been substantiated (i.e. triangulated) by theoretical perspectives stemming from two other bodies of knowledge: technology transfer and technological capability-building.

The study has revealed that technological capability-building through technology transfer involves factors that are categorised at individual and team level (i.e. micro level), organisational level (i.e. meso level), and sectoral, national and international level (i.e. macro level). Macro considerations are insufficiently treated by the above mentioned analytical perspective; accordingly, they have been further examined using the Innovation System analytical approach. The latter perspective dovetails with the knowledge-centred approach adopted in the evaluation, to which it is complementary. Specifically, an Innovation System framework has been applied at the satellite sectoral level. The aim being to appraise the embedment of the small satellite capability-building programme into its environment.

8.1.1 Technological learning

This study builds on knowledge typologies and learning theories that are suited to the technological context. In the latter, knowledge is often thought of as a resource that includes two complementary components, tacit and explicit knowledge, and seldom one component without the other. Accordingly, for learning to be effective in technological-based industries, there is a need to combine explicit (or codified) knowledge with implicit (or tacit) knowledge.

Learning conventionally occurs at the individual, group, organisational and inter-organisational level. The study builds on the idea that learning is a complex phenomenon and occurs on separate, but interrelated, levels. For learning to be effective, it should be systemic, involving intra- and inter-level processes.

Experiential learning theory has been used to support the argument that ‘learners’, whether they be individuals, groups, organisations, or inter-organisations, might be more effective when both reflection and action are combined during the learning process. Parallels were therefore drawn with the typology of technological learning, which identifies three types of learning: learning by doing (referring to action), learning by searching (referring to reflection) and learning by interacting (referring to intra- and inter-level interactions). When learning by doing, by searching and by interacting are combined, the learner's ability to learn effectively improves substantially.

Evaluation of learning has also been carried out by drawing on the concepts of knowledge 'viscosity' and 'velocity'. 'Velocity' refers to the speed with which knowledge is transferred, whereas 'viscosity' represents its richness. Successful transfer of knowledge is achieved through a delicate balance between velocity and viscosity.

The study has additionally built on the idea that the successful development of a technological product requires two types of knowledge: 'component' knowledge that relates to the core design concept of each product component, and 'architectural' knowledge that relates to the way that components are put together to form a system (i.e. product). It may be recalled that organisations with limited resources, such as those in developing countries, are forced to make a trade-off between architectural and component knowledge to successfully acquire technology.

The study highlights that absorption of new knowledge is a slow, sometimes long and laborious process. The technology acquirer's absorptive capacity is contingent upon their existing knowledge base (i.e. prior knowledge or accumulated knowledge) and intensity of effort. The former accumulates over time and grows through continuous learning that occurs under normal circumstances. The latter refers to the level of effort undertaken to assimilate new knowledge and pertains to the discontinuous learning that occurs under abnormal circumstances.

8.1.2 Technological capability-building

Technological capability is a concept that establishes the level of organisational capability attained through the dynamic process of technological learning.

Technological capability-building refers to the process of going beyond mere possession of knowledge. The latter should ultimately be employed towards generating new knowledge (i.e. creating and implementing new technology). Capabilities are embodied into physical investment, human capital, information (i.e. documentation), and management. They evolve on a complexity continuum from basic to higher, from skills required for simple tasks to skills required for complex tasks.

Technological capabilities in developing countries often derive from transferred technology. The process starts by acquiring technology in the form of ‘packages’ from abroad. From a technical perspective, an engineering effort is mostly required during this stage. Then, experience over this initial stage leads to indigenous development activities taking root, requiring indigenous engineering and development effort to achieve more sophisticated tasks. The technological capability process should finally reach the level of innovation when indigenous scientists and engineers possess the capacity to engineer, develop and research.

Consequently, this study was premised on the understanding that capabilities in developing countries are built according to the sequence: engineering, development, and research. This same sequence illustrates the complexity continuum, going from basic to intermediate and, ultimately, to advanced capabilities. What is more, technological capabilities have been examined by the combination of multiple factors at individual and team level (i.e. micro level), as well as organisational and firm level (i.e. meso level), and within a national, sectoral and international environment (i.e. macro level).

8.1.3 Technology transfer

The objective of technology transfer is to serve the purpose of local technological capability-building. Technologies transferred can also be embodied into physical investment, human capital, information (i.e. documentation), and management. These capabilities interact dynamically and operate simultaneously in managing the transfer process.

Multiple mechanisms are used to transfer technology. They are greatly affected by industry-specific factors (e.g. products and facilities), region-specific factors (e.g. cultural considerations), country-specific factors (e.g. the political and economic system), and organisation-specific factors (e.g. existent knowledge and management). The complexity that arises from the association of these factors with the available mechanisms indicates that there is no one-size-fits-all solution for developing countries. Each country has to seek its own solution to the transfer of technology. This study has focused on the mechanism of collaborative projects, which has been used by Algeria to transfer small satellite technology from abroad.

Successful transfer is highly dependent on the soundness of the linkages between the transferor and the transferee. Indeed, building sound linkages is underpinned by the convergence of mutual interests between the transferor and transferee. This mutuality is a matter of negotiation balance and bargaining power. It also depends on the ability of the transferee to adapt its technology transfer strategies according to the stages of technological development and lifecycle (i.e. mature, established or new). It likewise depends on the transferor’s ability to adhere to these strategies.

The study has emphasised that transfer success is predominantly a matter of the absorptive capacity of learners. The intensity of organisational effort has a more prominent role compared to that of prior knowledge, particularly for long-term learning. This intensity is translated through the actions of both continuous and discontinuous learning. This is particularly true in today’s fast-changing technological landscape, where knowledge does not always accumulate, and is not necessarily path-dependent.

Therefore, the study has argued that, in addition to the knowledge-accumulation perspective, the knowledge non-accumulation perspective is no less relevant for understanding the transfer of technologies in the knowledge-intensive satellite industry.

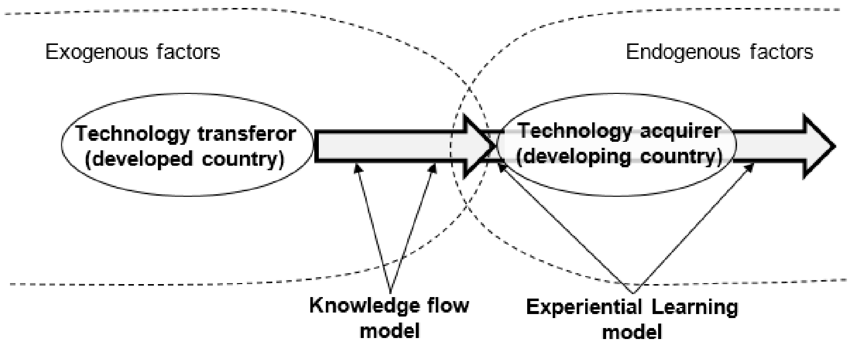
Cultural differences are another potential impediment to sound linkages and mutual understanding between transferor and transferee. In view of the complexity of the cultural construct, this study has limited itself to examining management practices at the organisational level that shape a learning culture and facilitate technology transfer.

The evaluation approach adopted in this study has taken into account the peculiarities of small satellite technology. It has explored satellites as complex systems (CoPS) and as systems developed under the FBC (Faster-Better-Cheaper) philosophy. Small satellite managerial challenges have been reviewed at individual, team, and organisational level. Managerial challenges that depend on the external environment have also been reviewed.

Due to the complexity of satellite technology, absorbing it is a slow and long process, particularly in developing countries. Therefore, the study posits that satellite technological learning does not lend itself to a traditional evaluative framework (i.e. summative or formative), which relies on the instrumental use of outcomes. A knowledge-generating approach has thus been adopted. Particular attention has been paid to a less aggregative level of analysis (i.e. individual and team) in order to capture 'micro' changes.

An evaluative framework has been devised. It has used the Innovation System analytical approach to examine the context (i.e. macro environment). The 'strategic planning' analytical tools have been used to evaluate the planning of the small satellite capability-building programme. The implementation of the latter has been evaluated through a framework that gathers 'triangulated' factors affecting technological learning, technological capability-building, and technology transfer; these factors are spread across different analytical levels (i.e. micro, meso, and macro). With technological learning having been placed at the heart of this evaluative approach, two systemic models were used to conduct the analysis. These models (i.e. the knowledge flow model and the experiential learning model) were devised by the author to evaluate the flow of knowledge from its initial conveyance (i.e. through the transferor-transferee relationship) to its local diffusion (Figure 8-1).

Figure 8-1: Positioning of the evaluation models



Source: Author.

The evaluation framework has been implemented through a mixed method research design. A quadrilateral data acquisition method has been adopted, and a mixture of quantitative and qualitative methods has been used. Data have also been collected from diverse sources. It is important to recognise that data have been collected under the particular settings of Algeria where different languages are often used and lack of research culture and secretive culture are common.

A comprehensive evaluation of Algeria's small satellite capability-building programme led to the following set of conclusions, listed in the next section.

8.2 Conclusions

This study offers a set of conclusions that stem from the evaluation findings synthesised in chapters 6 and 7. The evaluation first sought to analyse Algeria's technological context, then to analyse the elements that shape the sectoral satellite innovation system and its connections to the national environment. The study has critically appraised the strategic objectives of small satellite capability-building. The planning adopted towards achieving those objectives has also been examined. Following on from this, an evaluation of the implementation process was conducted using metrics related to technological learning, the expansion of locally-built technological capabilities, and technology transferred from abroad. Particular attention has been paid to management practices underpinning the capability-building process. The conclusions address macro, meso, and micro considerations.

In light of the above, this study offers the following conclusions:

Satellite capability-building, an 'isolated' and 'bureaucratic' process within a non-conducive national environment

Algeria's developmental trajectory has been characterised by poor/incorrect choices, inconsistencies, interruptions, short-sighted perspectives and a reluctance in adopting nationwide developmental policies and strategies (see chapter 6, section 6.2). This is evidenced by the poor results obtained under the planned economy model from the late 1960s to the late 1980s. It is also evidenced by Algeria's inability to transit effectively to a market economy since the late 1980s.

Algeria's development is heavily oil-dependent. Its economic, industrial and science and technology policies are subject to risks driven by volatility in oil prices. The government has dithered and has adopted no clear strategy to address this critical situation. The situation is further compounded by a post-independence ideological legacy and 'socialist' developmental model, which still factor heavily into decision making. In the late 1990s, Algeria attempted to lay down the foundations of a national innovation system. She adopted a systemic approach that covered the institutional aspects of the innovation system, its regulatory framework, planning with defined priorities, resource mobilisation, and incentive schemes. International technological partnerships were sought. However, the indigenisation capacity of local companies was limited. Companies faced a shortage of skilled human resources, equipment, time, incentives and an institutional framework. Foreign engineering and R&D

activities have therefore gradually eclipsed local activities, instead of having the opposite effect, i.e. enhancing local technological absorptive capacity.

In sum, Algeria has not succeeded in establishing an effective and consistent national innovation system. Despite all her efforts, weaknesses remain in terms of coordination, research promotion and industry-R&D synergy. The idea of building a satellite capability emerged bottom-up, from the lower echelons within this unfavourable industrial environment. The gradual recognition of the strategic value of satellite technology, and its potential applications in Algeria, has increased over time. In the late 1990s, it reached the level of maturity, resulting in the need to move from being a passive 'user' of satellites to becoming an engaged actor. A national space programme and a leading space agency were set up in the 2000s.

- ***Satellite capability-building: a process 'detached' from the national and international environment***

Algeria used the mechanism of collaborative small satellite projects to acquire technology from abroad and build local capability. Three collaborative projects were used (i.e. Alsat-1, Alsat-2, and Alsat-1B) and formed the backbone of the national space programme. The latter laid the foundations of a sectoral satellite innovation system. The present study has revealed that this innovation system is still burgeoning after nearly two decades of existence.

The study has also revealed that the satellite programme is detached from the local environment (see chapter 6, sections 6.3 and 6.4). It was devised and conducted without a thorough audit of the environment. The programme identifies ASAL and its operational entity CDS as 'prime movers' or 'system builders' for the development of satellite technology. However, the programme remains vague as to the involvement of local actors, particularly those meant to contribute to the development of satellite technology. Little is explicitly stated in the national space programme about technological and industrial actors, their roles, objectives and networking media. This is reflective of the weak linkages

ASAL has nurtured with the local environment. It also reflects ASAL's academia-esque posture, practices and corporate culture.

- ***Satellite capability-building: the prevalence of a bureaucratic approach***

The satellite programme was devised from a predominantly 'bureaucratic' perspective, wherein the role of the state became overstated (see chapter 6, sections 6.3 and 6.4). Market forces were entirely neglected. The exclusive source of funding envisaged by the programme was the state budget. The overt reason given is that the satellite sector is a fledgling industry, incurring significant learning costs and in need of protection. The present study questions whether this reason is fully valid after nearly two decades of the programme's existence.

Non-alignment of ASAL's strategic objectives with the collaborative project portfolio

Algeria seized the opportunity to leverage satellite collaborative projects to seed her own satellite development capabilities. Based on these projects, an overarching space programme was devised, for which three strategic objectives were stipulated: (i) development of industrial capabilities; (ii) satisfaction of national needs; and (iii) knowledge capability-building.

The present study reveals that ASAL has failed to translate these generic strategic objectives into goals aligned with the portfolio of collaborative projects (see chapter 6, section 6.4, chapter 7, section 7.3). This failure engendered confusion towards the primary goal of developing satellites. If the prevailing goal is 'technology application', then appropriate strategies usually stress downstream activities; for instance, through satellite image utilisation. Moreover, a highly risk-averse approach is generally adopted as the commitment towards end-users should be prioritised (e.g. the categorical need to deliver images to end-users).

On the other hand, when the prevailing goal is 'technology learning', suitable strategies usually stress design, manufacture and integration of satellite systems. Learning how to build satellites is the priority in these strategies. Higher risk is generally accepted, as learners are still building capabilities and skills.

By not prioritising objectives, ASAL failed to adopt clear goals and strategies. This leads to unclear direction being fed through to lower levels of management, researchers and engineers. The failure to define clear goals is also reflected in opaque requirements respecting the capability to be built and the technology to be developed. The findings reveal that the technology transferor in collaborative projects adopts a stance that ranges from flexibility, when transferring technology that has been exploited up to its limits and can be transferred without any risk, to rigidity, when transferring new and advanced technology. Acquisition of a variety of technologies, each with its own level of complexity and maturity, is virtually impossible for a resource-limited organisation such as ASAL. There is, therefore, a need to define clearly which technologies to target (e.g. system or subsystem) and which capability to build (e.g. design, development or integration). ASAL has failed in all these goals.

Confusion in defining goals is carried over into ASAL's poor planning of resources needed for small satellite development. Traditionally with small satellite technology, small incremental increases in resources (or investments) improve performance significantly, whereas large additional resources impact performance only modestly. The findings reveal that, paradoxically, ASAL's emphasis was on primary and 'heavy' investment to the detriment of small, simple and 'light' investment (see chapter 7, section 7.2).

The observed confusion in clearly defining objectives reflects the non-alignment of ASAL's goals and strategy with the collaborative projects (or project portfolio). Ideally, projects should be premised on ASAL's goals and be embedded in its strategy. If the goals are not clearly defined and the strategy not well thought through, it is difficult to know whether collaborative projects are the right projects, whether they are in conformance with the strategy, and whether they meet the stated objectives.

Disjointed planning of small satellite capability-building

ASAL did not rigorously plan the small satellite capability-building programme (see chapter 6, section 6.4). It has failed in establishing a strong nexus between planning levels. It has not adopted a recognised and rigorous process for developing strategic plans. Deficiencies in terms of planning are reflected in multiple gaps that exist in the strategic roadmap, which is the national space programme.

ASAL's plan is loosely grounded in the local environment. Substantial weaknesses in the assessment of this environment are revealed by the study. ASAL collected few data on the macro environment (e.g. political, economic, social, technological, environmental, and legal). No thorough audit has been conducted for collecting data on the industrial environment, competitors, suppliers, partners and funders. The gravity of this omission is such that, after some fifteen years from the first planning exercise (between 2002 and 2006), the weaknesses of the environmental assessment are still very much in evidence. For instance, aspects relating to intellectual property rights are still grossly neglected (i.e. a failure to fully assess the legal environment). Also, market forces are still neglected. The state budget is still seen as the exclusive source of funding, even with the risk posed by the volatility in oil prices.

ASAL's plan is effectively built on an unknown internal environment. The findings reveal that the internal environmental assessment was centred on exploitation and research activities (see chapter 6, section 6.4). Internal resources in terms of engineering and development were not properly assessed. This incomplete approach has blurred the lines between existing and intended capabilities vis-à-vis engineering and development. This is particularly unsettling since the spearhead of satellite development capability is the collaborative projects, and the latter are par excellence engineering and development projects.

Deficiencies in planning have predictably led to unclear strategic direction based on a distorted vision of ASAL's strengths, weaknesses, opportunities and threats. Accordingly, the action plan is substantially limited and unclear. It is limited, as it is exclusively translated through a portfolio of collaborative projects, leaving other options unexplored. No further actions or projects have been identified for building satellite capabilities. The action plan is unclear, because it is loosely cascaded over organisational, functional and individual levels. Its goals are not SMART (Specific, Measurable, Agreed-upon, Realistic, Time-based). For instance, no specific target is defined, no specific technology is targeted, very few generic metrics are defined, and an unrealistic schedule is proposed.

Evaluation of the planning for small satellite capability-building reveals that ASAL suffers from a chronic lack of awareness of planning tools.

Fragmentation, imbalance and inconsistency in implementation

Evaluation of the implementation process of the small satellite capability-building programme has led to the following subsidiary conclusions, covering several analytical levels (i.e. macro, meso and micro) and combining considerations related to technological learning, locally-built technological capability and technology transferred from abroad:

- ***Satellite capability-building: an ill-balanced process biased towards satellite application at the expense of satellite technology development***

The ASAL satellite capability-building process has fostered market demand for satellite applications and use of images (i.e. demand-side). However, it has virtually ignored the supply side that consists of building satellites and developing technology that can satisfy local needs.

Successful technology development policies are based on three interrelated types of measures: (i) policies intended to create and foster market needs for the technology in question (demand-side strengthening); (iii) policies intended to build technological capability that can satisfy needs (supply-side strengthening); and (iii) policies intended to link demand and supply sides. ASAL's satellite capability-building process has fallen into the 'traditional' trap of developing countries. The end-users (i.e. market) call for more technological products (e.g. satellite images), while ASAL does not have the technological capability to deliver the product. ASAL then faces an ill-balanced situation where it is hard to devise policies that effectively bridge demand and supply.

- ***Satellite capability-building: an ill-balanced process, biased towards research rather than development and engineering***

Building technological capability involves building complementary and balanced capabilities in terms of engineering, development, and research. The policy adopted should be adjusted to the need. If there is a need for research activities, the policy should be to promote investment in research. On the other hand, if there is a need for engineering and development activities, the policy should be to encourage market growth.

ASAL has taken a poorly balanced set of actions focused on research investment (see chapter 6, section 6.4, and chapter 7, sections 7.1 and 7.2). The research that has been conducted does not go beyond the laboratory setting. At the same time, far less attention has been paid to engineering and development, even though these two aspects are crucial for acquiring technology through collaborative projects.

Consequently, ASAL has failed in managing the balance between engineering, development, and research.

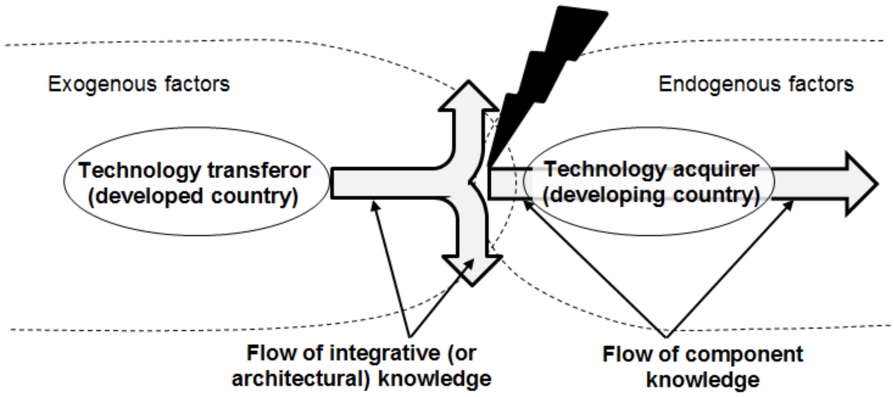
- ***Non-alignment of knowledge transferred from abroad with ASAL's locally developed knowledge***

ASAL has acquired knowledge from abroad during the various satellite collaborative projects. Following completion of the projects, ASAL has also built knowledge locally based on its endogenous resources. The findings reveal that knowledge acquired during the projects is mainly architectural (or integrative). This knowledge is organisational (or collective) in nature and perceived as 'gestalt', i.e. knowledge held by the organisation as a whole (see chapter 7, sections 7.1).

On completion of the projects, ASAL did not make the transition into an organisational learning entity. Its organisational arrangements are ineffective for acquiring architectural (or integrative) knowledge and developing it. Consequently, post-project knowledge is component-centred (or component knowledge) rather than architectural.

ASAL has thus failed in aligning the knowledge flowing out of the collaborative projects with the knowledge created after the collaborative projects had ended (Figure 8-2). In other words, ASAL has interrupted the architectural learning dynamic triggered during the collaborative projects, diverting it towards a component-centred learning dynamic.

Figure 8-2: Non-alignment in knowledge flow



Source: Author.

- ***Establishing a local satellite supply chain remains a distant goal***

Building a local supply chain relies on ASAL's interactions with other organisations involved in satellite development. ASAL's interaction density and continuity of interactions are virtually non-existent (see chapter 7, section 7.1). Building a local supply chain is also influenced by the technical architecture of the satellite, and whether its components can be insourced or outsourced. ASAL acquired a shallow form of satellite architectural knowledge. The latter was mostly engineering- & development-oriented, and was only acquired during the limited duration of the collaborative projects. Following completion of the projects, ASAL did develop certain component knowledge, albeit locally fragmented and research-oriented.

The distinct nature of the knowledge acquired through the capability-building process and its shallow and fragmented form reflect the limited satellite knowledge ASAL has developed, either in terms of architectures or components. No clear option is envisaged by ASAL for channelling resources towards less scattered efforts and for acquiring deeper knowledge consistently. Consequently, establishing a local satellite supply chain is not tenable at this stage.

- ***ASAL's satellite capabilities are fragmented and heterogeneous and do not go beyond the basic stage***

The analysis has identified the range of satellite capabilities built in Algeria and has attempted to characterise their levels of complexity (or sophistication) (see chapter 7, section 7.2). The identified capabilities take the form of physical investment, human capital, information (and documentation), and management. The levels of sophistication attained are reflective of the organisation's ability to progressively conduct tasks of operation and exploitation, engineering and AIT (assembly, integration and test), and specification and design.

The findings reveal that in terms of satellite operations and exploitation, ASAL has gradually built the physical investment, human capital, information handling, and the required management capabilities to enable local engineers to operate and exploit satellites independently. In terms of engineering and AIT, the findings reveal a paradoxical situation vis-à-vis physical investment. ASAL achieved primary and 'heavy' investment, but failed in achieving complementary, simpler and 'lighter' investment. The findings also reveal an imbalance in terms of human capital vis-à-vis engineering and AIT activities. Due to a major misalignment of incentives, only 20% of human resources are allocated to engineering, the rest is earmarked for research.

Moreover, information capabilities are only partially built and have not yet reached the organisational level. What is notable from the fieldwork is that building a dynamic and interactive organisational satellite technology memory is not a priority, as revealed by ASAL's ongoing initiatives.

The study notes the paradoxical status of certain capabilities when it comes to specifying and designing satellites. ASAL has built basic capability for specifying satellites, but it has virtually overlooked design capability. The paradox being that ASAL emphasised developing architectural knowledge during the collaborative projects. Architectural knowledge originates from knowledge of how a product is designed. This means that building architectural knowledge is largely predicated on the design phase, which in turn is the 'birth' phase of architectural knowledge. ASAL, however, have overlooked design capabilities.

In sum, ASAL has built a heterogeneous set of capabilities and the fragmented and non-systemic approach adopted has prevented ASAL from going beyond simple (or basic) use of technology, benefiting neither from development (i.e. intermediate-level actions) nor from innovation activities (i.e. advanced-level actions).

Chronic management deficiencies in Algeria's small satellite capability-building programme

The findings reveal that satellite capability-building in Algeria is a process that has been conducted from a bureaucratic posture detached from the national environment. This process has over-relied on an inappropriate mechanism of technology transfer, namely, the collaborative project (see chapter 7, section 7.3). Process planning was not rigorous. The implementation process has also resulted in a set of heterogeneous, fragmented, poorly balanced, and inconsistent capabilities (i.e. physical, human, and information). This is indicative of major deficiencies in terms of management capabilities, which are supposed to bring together, synergistically, the remaining capabilities.

ASAL's internal management deficiencies are only partly acknowledged within the organisation itself. The country-specific non-conducive environment is blamed for the 'mixed' outcomes of the capability-building process (see chapter 7, section 7.2). This attitude has distracted ASAL from taking a critical look at its internal managerial capabilities. Indeed, building internal managerial ability to solve problems offers increased flexibility in managing external factors that are out of its control.

The findings have revealed the following major management deficiencies:

- ***ASAL has inappropriately managed collaborative projects, and collaborative projects do not offer the appropriate framework for building the required management capabilities***

Collaborative projects are central to ASAL's strategy of building satellite capability. Effective transfer of technology, or learning, through collaborative projects was a major, perhaps even the primary, strategic objective of ASAL during the lifetime of these projects.

Effective learning relies primarily on the capacity of the two parties, ASAL and foreign companies, to identify a shared view of 'learning' during the projects, based on mutual interest. However, in the present context, the foreign companies' motives are economic, whereas ASAL's motives are primarily non-economic, aiming at acquiring new knowledge for building local capability.

This non-alignment of objectives has implicitly led to the adoption of project management tools that better serve the interests of foreign companies (i.e. technical, cost and scheduling) and omit those of ASAL (i.e. learning aspects) (see chapter 7, section 7.3). This omission largely explains the ambiguous perception ASAL have come to about learning performance during the projects. Indeed, there is a sense of frustration and dissatisfaction felt by ASAL's management over their inability to overcome learning barriers after three collaborative projects (i.e. Alsat-1, Alsat-2, and Alsat-1B). Additionally, rather than taking a critical look at the project management tools adopted during the projects, ASAL attributes responsibility to foreign companies (e.g. lack of willingness, non-cooperation).

The collaborative projects were led by foreign companies. ASAL did not exert effective project control. Consequently, a principal lever in the management of satellite development has remained under-exploited by ASAL. This is reflected, for instance, in the way risk was managed. Because the contractual responsibility lay primarily with the supplier, the common practice of ASAL representatives was to transfer risk to foreign companies. It was also reflected in the early phases of development, as satellites were built using technologies inherited from previous approved designs. Satellite design was not covered by this mechanism, and ASAL could not develop technical and managerial skills related to design.

- ***ASAL is a highly centralised organisation, which does not empower lower management levels***

Small satellite development is based on empowerment of teams and lower management levels. ASAL is highly centralised, particularly when it comes to managing small satellite development. Satellite development activities are formally located within one of ASAL's affiliates, namely CDS, which is located in the city of Oran, approx. 400 km out from Algiers. Despite the distance, ASAL contrives to over-manage as well as micro-manage satellite development activities. This situation could have been justified 10 or 15 years ago, at the dawn of Algeria's satellite programme, when 'decentralised' resources were missing. However, it is no longer justified, as the required resources are presently available in CDS, and, paradoxically, the entity which manages these projects in the parent organisation (i.e. ASAL) in fact lacks appropriate resources.

ASAL's inability to empower CDS has induced an inability in CDS to effectively coordinate its internal 'inter-group' activities. ASAL's highly centralised management posture has resulted in severe communication and interaction shortfalls at all management levels. Individual and group learning is scattered and poorly aligned with the goal of small satellite development. Consequently, ASAL as a learning organisation is far from a coherent entity.

- ***Poor management practices, burdened with administrative and bureaucratic tasks***

There is a severe lack of training related to management functions for small satellite development (see chapter 7, sections 7.2 and 7.3). ASAL's personnel have had little to no formal training in management tools and techniques. A severe lack of awareness is apparent with regard to crucial management practices, such as putting in place learning routines, implementing a quality assurance approach that relaxes or eliminates bureaucratic procedures, formally and explicitly managing individuals and groups, particularly those who hold tacit knowledge, by singling them out and by attributing value to their work, and separating project management tasks from technical (systems engineering) tasks.

ASAL's responsiveness to lower management levels and project teams in particular is poor in spite of its many years' experience. These management levels are loaded down with extra-resources and are, consequently, burdened with administrative and bureaucratic tasks, being done to the detriment of the main mission.

Despite the many challenges faced by ASAL, especially the severe lack of managerial skills and capabilities, no clear strategies or measures have been adopted or planned going forward to address these issues. This situation reflects a chronic lack of awareness of the preeminent role of management in developing satellite capabilities.

8.3 Recommendations

The non-conducive domestic environment is a major constraint on Algeria's technological development. Algeria has proved ineffective in building a consistent national innovation system into which small satellite development can be integrated. This leads to two fundamental precepts that underpin the validity of the below recommendations. Firstly, ASAL should explicitly recognise the complexity of a 'national' perspective and the need to adopt an intermediate sectoral perspective through building a satellite innovation system. Secondly, ASAL has been tentative in its undertaking. Its satellite capability-building process has been visibly slow in delivering tangible outcomes. To avoid stagnation, ASAL should recognise that the stepping-stones to achieving its objectives are not readily discernible and prima facie obvious, and it should gradually explore and evolve its strategic vision.

Therefore, the recommendations, as derived from the conclusions (section 8.2), are as follows:

ASAL needs to clearly articulate a strategy for the development of small satellites

ASAL is a limited-resource organisation. It is thus recommended that it narrow the scope of its activities. A plausible option would be that ASAL develop internal satellite assembly, integration, and test capabilities (i.e. architectural knowledge). In parallel, some crucial components should be insourced (i.e. component knowledge), whereas "non-bottleneck" components should be outsourced.

This strategic choice might be perceived as inconsistent with Algeria's objective of generating local value through establishing a national satellite industry. Assembly, integration, and test operations in the particular case of small satellite technology should not be underestimated and viewed as mere 'screwdriver' operations. The ability to conduct such operations is vital in small satellite development, notably when the industry trend is towards bringing together commercial off-the-shelf components, where little component knowledge is required. On the other hand, given the interwoven nature of satellite integrative and component knowledge, the choice of components to insource should be based on how strongly coupled they are with the architectural capabilities ASAL intends to build.

ASAL needs to dissociate the strategic objective of 'satellite technological learning' from that of 'satellite application'. It also needs to clearly prioritise the objective of 'technological learning' for small satellite capability-building.

This should clear up confusion as to the implementation mechanisms ASAL needs to adopt. It implies that larger risk margins are acceptable and lower management levels, engineers and researchers would be more learning-focused and risk-tolerant or risk-disposed. Prioritising technological learning also implies clear identification of the technology being targeted. However, the disconnect between the objectives of 'satellite technological learning' and 'satellite application' should not prevent ASAL from devising balanced policies linking the demand and supply sides of satellite technology by narrowing these two market forces. It is recommended that ASAL develop market segments requiring less sophisticated technology. ASAL should concurrently channel efforts towards developing less sophisticated technology.

ASAL's isolation from its external environment has had a detrimental effect on satellite capability-building. To maintain the momentum, there is an urgent need to establish a strong foothold in this environment.

This can be realised using a two-pronged approach; namely, the setting up of a local supply chain and establishing connectivity to the global supply chain.

Policies and actions intended to build local industrial capability should be detailed and explicit. They should recognise the government's role in developing the satellite industry, without conflating it with a bureaucratic state-centred vision. For instance, there is a need to overcome ASAL's academia-esque culture which carries with it the deficiencies inherent to university-industry and research-industry linkages. It is recommended that ASAL diversify its human resources component by including personnel from the private sector and industrial environment having first-hand knowledge of linkages with industry.

A technology transfer programme from ASAL to local industry should be devised. Accompanying measures for upgrading local actors in order that they comply with space industry requirements should be envisaged. Considerations of intellectual property rights should be included. Funding options and other incentives towards local actors should be addressed. In order to break ASAL's bureaucratic and state-centric vision, private sector participation should be encouraged. Market forces should be addressed. Protectionist policies towards the burgeoning satellite capability should be intended to overcome resource limitations for a limited time only. Any protectionism intended to address market failures (e.g. factors outside the remit of organisations: institutional, infrastructure inappropriateness and labour market deficiencies) will be ineffective unless market-based measures are taken.

The local satellite supply chain should leverage segments of other local supply chains with which elements are shared (e.g. automotive and electronics). Given increasing 'geographical' fragmentation of the satellite industry worldwide, ASAL should stimulate local actors to join segments of the global chain. Ultimately, local activities should be driven by the requirements of the international satellite industry market.

ASAL would benefit from undertaking a comparative evaluation of strategies and international experiences of satellite industry development.

The South Korean and Indian experiences are highly relevant to Algeria, especially in the way these countries have continuously aligned their strategies and implementation mechanisms with their objectives. Lessons can be learned from how South Korea brilliantly aligned local development efforts with architectural knowledge acquired from abroad. Their experience is instructive in terms of transforming government-led satellite organisations from bureaucratic and research-centred organisations into managers and supporters of satellite industry development. India's experience is particularly relevant in view of the way that they cleverly diversified international partners as a strategic choice to increase technology transfer opportunities. India's case is also apposite for the way they built a local supply chain, as well as strong engineering and development sectors.

ASAL should seek a balance between engineering, development, and research capabilities.

To strengthen ASAL's engineering and development capabilities, it is recommended that it develop internal capabilities by adopting appropriate incentive regimes. In parallel, it should encourage the development of external capabilities by gradually enlarging the size of its satellite market. This could be enabled by increasing the number of projects, diversifying themes and encouraging the entry of new local suppliers into the value chain segments. To foster a local satellite supplier network, ASAL should devise technology transfer programmes from its industrial facilities to public and private companies. Such programmes should include training, sharing of information and facilities, prototype development, and applied R&D.

ASAL's research network should be re-shaped, and applied research and development capabilities should be put in place. They should be internal to ASAL and its immediate environment (e.g. partners, specialised research centres, companies). At this stage, activities should be entrusted to government-sponsored organisations. In parallel, ASAL should enforce intellectual property regulation to promote activities within companies (private and public). Given the high-risk nature of satellite technology, further incentives should be provided to ASAL's partners. Basic research should be assigned to universities (e.g. by channelling EDTAS activities).

ASAL should align its locally created knowledge with knowledge acquired from abroad.

To promote learning alignment, ASAL should adopt a number of strategies. ASAL has acquired architectural knowledge from abroad and the priority must now be to build 'architectural' capabilities locally, which can absorb and enrich this knowledge. It should encourage density and continuity of interactions, internally and with its external partners, as part of the effort to expand the local supply chain. ASAL should establish continuous and dense interactions with the organisations already identified as forming part of the local supply chain (i.e. ECA and CDTA). Based on a thorough external audit, ASAL should bring new actors into its supply chain from the public and private sectors. It is strongly recommended that ASAL promote local supply chains within the electronic and mechanical engineering industries. Algeria's burgeoning automotive supply chain should particularly be explored. ASAL should devise policy towards incentivising such actors, turning them into space-compliant industries (i.e. using incentives, risk management and cost-benefit analysis).

ASAL should also develop internal satellite design capabilities as they largely explain endogenous architectural knowledge, essential for attaining technological independence. Design capabilities should incorporate, from the outset, the technical architecture of the system to be developed, as this can aid in shaping ASAL strategy (e.g. on whether parts of a system should be insourced or outsourced). ASAL should also decide on the trade-off between using custom or standard components (i.e. off-the-shelf components).

Management capability-building must be ASAL's absolute priority.

To overcome ASAL's chronic managerial deficiencies, a thorough plan for building managerial capability is strongly recommended. Such a plan might include some of the following points:

- Planning capabilities should be built and rigorous planning tools should be adopted to cover all planning levels. At the strategic level, for instance, ASAL personnel should be trained in strategic management/planning.
- ASAL will also benefit by training its personnel in areas such as technology management/planning, leadership and innovation management.
- ASAL should build internal capabilities for managing issues regarding intellectual property rights.
- ASAL should set up a permanent internal mechanism for learning evaluation based on knowledge-generating approaches. At the project level, project

management tools and techniques, particularly those addressing learning as a strategic objective, should be adopted.

- There is a need to adopt new mechanisms for developing small satellites, handing over the management of satellite projects to ASAL. They should foster local development by entwining ASAL's engineers with the local environment, instead of seconding them to foreign countries for extended periods of time, disconnected from local realities.
- To enable empowerment of lower management levels, there is a need to build trust through clarity of objectives, rigorous action plans, and appropriate lower-level managerial capabilities. ASAL should provide more visibility on objectives and plans by sharing information and communicating extensively with its personnel. A culture of risk-tolerance and innovation must be encouraged through appropriate incentives. Communication should help align individual activities with group and organisational objectives.
- ASAL should adopt small satellite project management practices. It should distinguish between technical tasks and project management. ASAL and CDS should, *a priori*, build up a reservoir of resources and deliver them to project teams whenever needed. CDS needs to adapt its organisational structure to ensure better communication and coordination. CDS should also entrust a 'principal investigator', who will be in charge of technical and scientific coordination.

8.4 Proposals for further research

The present study is one of only a few empirical researches addressing satellite technology development in developing countries. The following research directions can be pursued to extend the work herein and address remaining open questions.

8.4.1 Choice of small satellite technology for developing countries

Prioritising satellite technological learning by developing countries implies a clear identification of the technology to be targeted. It is appropriate to conduct research on the selection of the suitable small satellite technologies for those countries; technologies that are aligned with the absorptive capacity of these countries. Such a research would entail a review of emerging trends in small satellite technology and their appropriateness to conditions in developing countries. Technological forecasting techniques would be critical in this research.

8.4.2 'Generalisation' potential of knowledge flow and experiential learning models

Technological learning should be placed at the heart of any knowledge-generating evaluation of technology transfer from developed to developing countries. This study has the merit of proposing and testing two models (i.e. the knowledge flow model and experiential learning model) devised for evaluating satellite knowledge flow from the genesis of the transferor-transferee relationship to its local diffusion. The author believes that these models have the potential for 'generalisation' to other technologies, provided that they are empirically tested, enriched and adapted through further research.

8.5 Summary of findings and recommendations of the programme evaluation

From the foregoing, the major findings of the evaluation of Algeria's small satellite capability-building programme and the associated recommendations are summarised in Tables 8.1, 8.2 and 8.3. The principal overarching policy messages revealed by this study are that ASAL has failed to establish a strong foothold in its environment through a local supply chain and that clear strategies with prioritised objectives need to be adopted. Also, ASAL as a coherent learning entity does not yet exist. Its actions are inconsistent, fragmented, and ill-balanced, and there is an urgent need to build management capabilities effectuating synergy for coherent organisation. Finally, ASAL's actions are not aligned with its objectives, and there is a need to adopt appropriate mechanisms and a diversified project portfolio.

Table 8-1: Findings and recommendations at macro level

Findings	Recommendations
-The satellite programme is 'detached' from the national and international environment (ASAL has failed in creating a local supply chain) -The satellite programme is implemented through a bureaucratic approach with an outsize role played by the state -The satellite programme is ill-balanced, i.e. biased towards satellite application at the expense of satellite technology development -The satellite programme is ill-balanced, biased towards research, rather than development and engineering	-ASAL needs to dissociate the strategic objective of 'satellite technological learning' from that of 'satellite application'. -ASAL needs to clearly prioritise the objective of 'technological learning' for small satellite capability-building -ASAL should narrow the scope of its technological development activities -ASAL needs to establish a strong foothold in its external environment through the setting up of a local supply chain and connectivity with the global supply chain -ASAL should seek a satellite sectoral balance between engineering, development, and research capabilities

Source: Author

Table 8-2: Findings and recommendations at meso level

Findings	Recommendations
-ASAL does not act as a coherent learning entity -ASAL has acted as a highly centralised organisation and does not empower lower management levels -ASAL has failed in aligning goals and strategy with implementation tools (i.e. collaborative projects) -ASAL's capabilities are fragmented and heterogeneous, and are at a basic stage of development -ASAL has managed the satellite capability-building programme inappropriately (i.e. poor management practices)	-Organisational management capability-building must be ASAL's absolute priority -ASAL should seek an internal balance between engineering, development, and research capabilities -ASAL needs to adopt rigorous planning tools

Source: Author

Table 8-3: Findings and recommendations at micro level

Findings	Recommendations
-ASAL has failed to align the satellite knowledge transferred from abroad, through collaborative projects, with ASAL's locally developed knowledge -ASAL has managed the collaborative projects inappropriately -ASAL's individual- and team-level resources are fragmented	-Appropriate mechanisms and a diversified project portfolio need to be adopted -Appropriate collaborative project management tools need to be adopted -ASAL should align its locally created knowledge with knowledge acquired from abroad

Source: Author

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Appendices

Appendix 1-a: Questionnaires for team members (English version)

Date:	Participant ID:

Questions on building small satellite capabilities in Algeria

Addressed to Alsat-1 project team members

Research aim: To collect data in order to gain better understanding of satellite technology transfer to Algeria. This will enable Algerians to gain an appreciation on the effectiveness of the mechanisms that they have used to build satellite technological capabilities, and will provide guidance regarding effective processes to transfer satellite technology.

Guidance in responding to questions:

- Please feel free to use Arabic, French or English when responding.
- Some responses require circling a number ① or ticking a box **V**, some other responses require written comments. If the space provided on the form is insufficient for your comments, use additional sheets as required. Feel free to include any additional material deemed relevant.
- Once you have responded to questions, the researcher will be interviewing you by himself in a face-to-face meeting to ensure proper understanding of questions and responses.
- All responses will be treated as confidential with only the researcher having access to them. Your identity will not be revealed and you will remain anonymous. You will be only identified as Participant A, B, C, etc.

Sections covered:

A. General information
B. Activities as part of the project
C. Activities after the project
D. Final suggestions

A. General Information

1) What is your educational background? Indicate the corresponding educational organisations and time frame (Please indicate from the "Baccalaureat").

Education/Degree	Time frame	Educational organisations

2) What is your professional background? Indicate the corresponding organisation and time frame.

Positions/ Professional responsibilities	Time frame	Organisations

3) Before you participated in this project, have you ever participated in any project or activity involving foreigners (e.g. joint project, negotiations, joint R&D, etc.)?

4) When did you join the project team? Why and how were you selected for the project? Describe the entire process.

5) How long before the beginning of the project were you informed of your selection?

6) Did you participate in any preparatory activity related to the project before its beginning? (For example: technology assessment, project negotiation with the firm, design or specification study, introductory sessions, practical training, theoretical training, language training, etc.). Explain what were these activities? How useful were they? How appropriate were their durations? How would have they been performed for better result?

7) How often did you meet (formally or informally) senior leaders from your organisation before the beginning of the project in order to discuss about the project? Who were they? In which occasion and what was the aim of the meeting?

8) How motivated were you before the beginning of this project?

Circle the appropriate number

My motivation was				
Low				High
1	2	3	4	5

-Why? What motivated you most, what motivated you less?

B. Activities as part of the project

9) In which component(s) (e.g. unit/module/sub-system/system) or function(s) were you specialised? Tick the appropriate box or boxes. Indicate how deep were you involved in components and functions other than those you specialised in.

component(s) (e.g. unit/module/sub-system/system) or function(s)	I was specialised in this/these component(s)	My involvement in this/these components/functions was				
		Not deep			Deep	
Space Segment		1	2	3	4	5
Platform		1	2	3	4	5
Structure		1	2	3	4	5
Thermal control		1	2	3	4	5
On-board power supply		1	2	3	4	5
Attitude control		1	2	3	4	5
Data handling		1	2	3	4	5
Payload		1	2	3	4	5
Integration, Assembly, and Test		1	2	3	4	5
Spacecraft Integration		1	2	3	4	5
Payload-to-spacecraft Integration		1	2	3	4	5
Satellite Testing		1	2	3	4	5
Ground Support Equipment-GSE		1	2	3	4	5
Ground Segment		1	2	3	4	5
Mission Control		1	2	3	4	5
Payload Control		1	2	3	4	5
Communication System		1	2	3	4	5
Support Functions		1	2	3	4	5
Management task (Programme Management)		1	2	3	4	5
Engineering tasks (System Engineering)		1	2	3	4	5
Product assurance tasks		1	2	3	4	5
Training		1	2	3	4	5
Launch, Operations and Maintenance		1	2	3	4	5
Launch		1	2	3	4	5
Operations and Maintenance		1	2	3	4	5
Other						

10) Where and how was developed the component you specialised in? (Designed, built partially, integrated, tested, completely by the firm within its facilities, or partially, etc.).

-If the component was developed partially or entirely outside the firm, to what extent were you involved to the outside development (e.g. participating in the development, or trained, within the suppliers/subcontractor's facilities, meetings/exchange)? Describe how was the technical collaboration between the Prime and the Suppliers/Subcontractor carried out? And how deep was the knowledge of the Prime (foreign firm) about the component and why did it rely on the supplier/subcontractor?

11) With regard to the components/functions you specialised in, what was your role (duties/mission/objectives)?

component(s) or function(s) you specialised in	duties/mission/objectives

-How appropriate did you find your prior knowledge (background/skills/knowledge/profiles) to the requirements of the components/functions you specialised in?

Circle the appropriate number for each component/function you specialised in

component(s) or function(s) you specialised in	My prior knowledge was				
	Less than requirement		close to requirement		beyond requirement
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5

-Why? and what was the most needed knowledge?

-How clear did you find the objectives of your participation in the project?

Circle the appropriate number for each component/function you specialised in

component(s) or function(s) you specialised in	I found the objectives				
	Not clear				clear
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5

-Why?

-How ambitious did you find the objectives of your participation in the project?

Circle the appropriate number for each component/function you specialised in

component(s) or function(s) you specialised in	I found the objectives				
	Not ambitious				Ambitious
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5

-Why?
-What kind of training you participated in during the project?

Fill in the appropriate cells and Circle the appropriate number for each training type

Training type	Duration	How the training was controlled and monitored (Academic evaluation, tests, dissertation, presentation, practical tasks, etc.)	How appropriate did you find the training for the rest of your activity	
			During the project	After the project
			Inappropriate Appropriate	Inappropriate Appropriate
Theoretical training (Academic courses, Project focused courses, etc.)			1 2 3 4 5	1 2 3 4 5
Practical training (Performed on non-real system such as tasks, projects, experiments, etc.)			1 2 3 4 5	1 2 3 4 5
On the Job training (Practical work performed on the actual system)			1 2 3 4 5	1 2 3 4 5

12) With regard to the components or functions you specialised in, how deep did you find the knowledge you acquired during the project?

Circle the appropriate number for each component/function you specialised in

component(s) or function(s) you specialised in	I find the knowledge
	Not deep Deep
	1 2 3 4 5
	1 2 3 4 5
	1 2 3 4 5
	1 2 3 4 5

- Why? (Give explanation on whether the required disciplines were covered, was the time spent sufficient? was the number of Algerians trained sufficient? Was this knowledge focused on components architecture, integration process, or on particular aspects of the component you specialise in, etc.? What would be the right number of trainees and the right background to effectively acquire knowledge?

13) With regard to the components or functions you were involved in (not specialised in), how deep did you find the knowledge you acquired?

Circle the appropriate number for each component/function you were involved in (not specialise in)

component(s) or function(s) you were involved in (not specialised in)	I found the knowledge
	Not deep Deep
	1 2 3 4 5
	1 2 3 4 5
	1 2 3 4 5
	1 2 3 4 5

-How and Why?

14) During your participation in the project, what were the project phases in which you took part?

Project Phases	Phase description	What were your Mission/duties/objectives	My involvement in this/these phases was				
			Not deep				Deep
Phase 0	Mission analysis/needs identification, where mission aims and functions to be performed are defined		1	2	3	4	5
Phase A	Feasibility, where mission general concepts and system functional requirements are defined		1	2	3	4	5
Phase B	Preliminary Definition, where sub-systems functional requirements are defined, all activities and resources for the project development are identified, and preliminary risk assessment is carried out		1	2	3	4	5
Phase C	Detailed Definition, where the detailed technical and functional specifications of the space and ground segments are defined		1	2	3	4	5
Phase D	Manufacturing, Assembly and Testing, where the development and qualification of the system (space and ground segment) and its products (images) are carried out		1	2	3	4	5
	-Procurement (of service or equipment, from third-party)		1	2	3	4	5
	-Manufacturing/development (either within the firm or outside the firm)		1	2	3	4	5
	-Assembly (either within the firm or outside the firm)		1	2	3	4	5
	-Testing (either within the firm or outside the firm)		1	2	3	4	5
Phase E	Launch and operations of the system, where activities related to launch, commissioning, maintaining space segment orbital elements and utilising ground segment are performed		1	2	3	4	5
Phase F	Disposal, referring the activities needed to put the system at customer's (or operator's) disposal		1	2	3	4	5
Other							

Give further details if required?

15) Describe the phases in which you participated?

Fill in the appropriate cells and Circle the appropriate number for each phase

Phase in which you participated	Duration of your participation (days/hours)	What types of training were provided	Was the time you spent in this phase sufficient to effectively acquire knowledge?	How appropriate you find the training for your activity	
				During the project	After the project
			Insufficient Sufficient	Inappropriate Appropriate	Inappropriate Appropriate
			1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
			1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
			1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
			1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
			1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
			1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
			1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Give further details if required.

16) During your participation in the project, what were the project meetings/reviews in which you took part?

Circle the appropriate number for each meeting/review

Meetings/reviews	To what extent you have contributed in these meetings/reviews? I have	To what extent you have learnt from the contributions of other participants? I have
	Not contributed … Contributed heavily	Not significantly learned … Significantly learned
Mission Definition Review-MDR	1 2 3 4 5	1 2 3 4 5
Preliminary Requirements Review-PRR	1 2 3 4 5	1 2 3 4 5
System Requirements Review-SRR	1 2 3 4 5	1 2 3 4 5
Preliminary Design Review-PDR	1 2 3 4 5	1 2 3 4 5
Critical Design Review-CDR	1 2 3 4 5	1 2 3 4 5
Qualification Review-QR	1 2 3 4 5	1 2 3 4 5
Acceptance Review-AR	1 2 3 4 5	1 2 3 4 5
Operational Readiness Review-ORR	1 2 3 4 5	1 2 3 4 5
Flight Readiness Review-FRR	1 2 3 4 5	1 2 3 4 5
Launch Readiness Review-LRR	1 2 3 4 5	1 2 3 4 5
Commissioning Result Review-CRR	1 2 3 4 5	1 2 3 4 5
End-of-life Review-ELR	1 2 3 4 5	1 2 3 4 5
Mission Close-out Review-MCR	1 2 3 4 5	1 2 3 4 5
Other		

Give further details if required.

17) How often did you meet (formally or informally) senior leaders from your organisation during the project in order to discuss about the project? Who were they, in which occasion and what was the aim of the meeting?

18) How reliable was the component you specialised in?

Tick the appropriate box for each component you specialised in

component(s) you specialised in	The component reliability was					
	Less than 70%	Between 70 and 80%	Between 80 and 90%	Between 90 and 95%	Between 95 and 99%	More than 99%
	☐	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐	☐

19) How complex was the component you specialised in? Considering that complexity is a mix of: Number of developed/customised sub-components required for developing the component, Number of skills (diversity) required, and New knowledge required.

Circle the appropriate number for each component you specialised in

component(s) you specialised in	I found the component complexity				
	Ordinary				High
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5

-Why?

20) How do you find the performances of the component(s) you specialised in?

Circle the appropriate number for each component you specialised in

component(s) you specialised in	I found the component performances				
	Low				High
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5

-Why?

21) How do you find the share of COTS (Commercial off-the-shelf) in the components?

Circle the appropriate number for each component you specialised in

component(s) you specialised in	I find COTS components share				
	Low				High
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5

22) How do you find the share of mature elements in the components? (e.g. Technology that has an established heritage in space usage, technology that scores high on the scale of Technology Readiness Level-TRL or Manufacturing readiness level-MRL)

Circle the appropriate number for each component you specialised in

component(s) you specialised in	I find mature elements share				
	Low				High
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5

23) With regard to the component you specialised in, how do you find the knowledge provided by the foreign company during the project for each of the following characteristics:

a/ In terms of Newness (compared to the knowledge already available in this sector)?

Circle the appropriate number for each component you specialised in

component(s) you specialised in	I found the provided knowledge
	Old New
	1 2 3 4 5
	1 2 3 4 5
	1 2 3 4 5
	1 2 3 4 5

-Why?

b/ In terms of Breadth (diversity of disciplines involved in the component you specialised in)?

Circle the appropriate number for each component you specialised in

component(s) you specialised in	The provided knowledge involved
	Few disciplines Multitude of disciplines
	1 2 3 4 5
	1 2 3 4 5
	1 2 3 4 5
	1 2 3 4 5

-Why?

c/ In terms of Depth (Depth in the disciplines involved in the component you specialised in)?

Circle the appropriate number for each component you specialised in

component(s) you specialised in	The provided knowledge was
	Not very deep Very deep
	1 2 3 4 5
	1 2 3 4 5
	1 2 3 4 5
	1 2 3 4 5

-Why?

24) In your view, how complex was the whole satellite system? Considering that complexity is a mix of: Number of developed/customised components required for the satellite system, Number of skills (diversity) required for the satellite project, and New knowledge required for the satellite project.

Circle the appropriate number

I found the satellite system complexity
Ordinary High
1 2 3 4 5

-Why?

25) How do you find the performance of the whole satellite system?

Circle the appropriate number

I found the satellite system performances				
Low				High
1	2	3	4	5

-Why?

26) List the engineering tools, equipment, software and facilities used for the development of the component you specialised in?

Phases	The engineering tools, equipment, software and facilities		
	Used by the foreign company	You used yourself during the project	That are available in your facilities in Algeria (or can be easily found elsewhere in Algeria)
During the specification and design			
During the procurement			
During the development			
During the Assembly			
During the integration			
During the test			
During the launch and operations			
Other			

-If engineering tools, equipment, software and facilities required for the development of the component/function in which you specialised are not available (or missing) in your facilities in Algeria, tell how important are they? and can they be acquired?

27) List the documentation and knowledge resources used for the development of the component you specialised in?

Phases	The documentation and knowledge resources		
	Used by the foreign company	You used yourself during the project	That are available in your facilities in Algeria (or can be easily found elsewhere in Algeria)
During the specification and design			
During the procurement			
During the development			
During the Assembly			
During the integration			
During the test			
During the launch and operations			
Other			

-If the documentation and knowledge resources required for the development of the component/function in which you specialised are not available (or missing) in your facilities in Algeria, tell how important are they? Why couldn't they be acquired? Have you attempted to reproduce them (or some of them)?
-With regard to the project documentation and knowledge resources brought in Algeria, how are they managed? Where are they? How easy are they accessible? Who has access to them? Has this documentation been used since then?

28) On the basis of the knowledge acquired during the project (either through written or unwritten resources), have you attempted to prepare any documentation (e.g. theoretical documentation, practical documentation, report/routines/tests/procedures, etc.) for the internal use within your organisation in Algeria? and how important is this documentation for performing independently tasks in Algeria?

29) On the basis of the knowledge acquired during the project (either through written or unwritten resources), have you attempted to conduct any R&D work, published or not published, (e.g. journal papers, conferences papers, study reports, patent, etc.)? How many works have been done? Who are the persons involved and to which organisation they belong?

30) List the human skills/resources required for the development of the component you specialised in?

Phases	The human skills/resources	
	Used by the foreign company	That are available in your facilities in Algeria (or can be easily found elsewhere in Algeria)
During the specification and design		
During the procurement		
During the development		
During the Assembly		
During the integration		
During the test		
During the launch and operations		
Other		

-If the human skills/resources required for the development of the component/function in which you specialised are not available (or missing) in your facilities in Algeria, tell how important are they? How difficult can they be developed or acquired?

31) What was the work language during the project? How comfortable were you with this (these) language(s)?

Circle the appropriate number for each language used in the project

Language(s)	I was
	Less comfortable Very comfortable
	1 2 3 4 5
	1 2 3 4 5
	1 2 3 4 5

32) During your participation in the project, how many mentors did you have and how long have you been under their mentoring?

Mentor (s)	Time spent with the mentor

33) How would you describe your work relationship with your mentors during the project?

Circle the appropriate number for each mentor you got in the project

Mentor (s)	Intensity of relationship	Formality of relationships	Difficulty of relationships
	Non-intense (mild) — Very intense	Informal (not well defined, flexible) — Formal (well defined)	Easy and not conflicting — Difficult and conflicting
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

-Give further details if required: (For example, He couldn't provide further knowledge because of restrictions from his company, protection of the technology, contractual terms, the two personalities were different which made communication not easy, etc.)

34) How would you describe your mentors knowledge and pedagogical capabilities?

Circle the appropriate number for each mentor you got in the project

Mentor	Theoretical knowledge of the mentor	Practical knowledge of the mentor	Pedagogical capabilities
	Limited — Extensive	Limited — Extensive	Limited pedagogy — High pedagogy
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

-Give further details if required, and give indication on the amount of knowledge you acquired from him and why couldn't you acquire everything (for example, he has limited knowledge, he lacks communication, the language he used were difficult to understand, the knowledge conveyed was not enough detailed, the knowledge conveyed cannot be easily explained, the knowledge was conveyed using unusual codes, symbols, frameworks, the time spent with him was not sufficient, your initial knowledge on the matter was limited and you needed to first update your knowledge and then follow with him, etc.)

35) When, how often and to whom did you use to report (and give feedback) on the work progress during the project? (to the mentor, to the Algerian team leader, Was this done regularly, occasionally when situation were deemed un-acceptable, formally, informally, etc.?) Did you experience situations where you raised issues/questions? How autonomous were you in dealing with these issues/questions?

36) How would you describe your work relationship during the project with colleagues working on the same component(s) you specialised in?

Circle the appropriate number for each colleague working on the same components

colleagues	Intensity of relationship	Formality of relationships	Difficulty of relationships
	Non-intense (mild) — Very intense	Informal (not well defined, flexible) — Formal (well defined)	Easy and not conflicting — Difficult and conflicting
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

-Give further details if required:

37) How would you describe your work relationship during the project with colleagues working on other satellite components/functions (not the component you specialised in)?

Circle the appropriate number for each colleague working on other satellite components/functions (e.g. team leader, system engineering, AIT, Power, Payload, etc.)

colleagues	Intensity of relationship	Formality of relationships	Difficulty of relationships
	Non-intense (mild) Very intense	Informal (not well defined, flexible) Formal (well defined)	Easy and not conflicting Difficult and conflicting
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

-Give further details if required:

38) Describe how were you involved in tasks related to the integration of the whole satellite system?

-How deep was this involvement?

Circle the appropriate number

My involvement in the integration of the whole satellite was
Not deep Very deep
1 2 3 4 5

39) Rank from " 1" to "5" the following sources of knowledge in order of contribution on the whole knowledge you acquired during the project?
e.g. "1" being the source that contributes the most in the knowledge you acquired during the project.

Sources of knowledge	Rank	Give details if necessary
Mentor(s) (judgement and appreciation)		
Other individuals and experts (judgement and appreciation)		
Project documentation and databases (blueprints, handbooks, workbooks, guides, system requirements, specifications, interfaces, implementation plans and procedures, test routines, reports, etc.)		
Libraries (books, specialised publications and journals, etc.)		
Other		

40) Based on your experience, which of the following statement matches your view most closely on the focus of the knowledge you acquired during the project?

Tick the appropriate box

	Disagree	Tend to disagree	Tend to agree	Agree
The provided knowledge was focused on the component you specialised in as an independent component	☐	☐	☐	☐
The provided knowledge was focused on the component you specialised in as part of the whole system or satellite (e.g. interaction with other components, process of integration within the larger system, etc.)	☐	☐	☐	☐

41) Based on your experience, which of the following statement matches your view most closely on the risk the foreign company was taking when it provided training on the component you specialised in?

Tick the appropriate box

	Disagree	Tend to disagree	Tend to agree	Agree
I feel the training provided was about a technology that has been exploited up to its limits and can be transferred without any risk (e.g. risk of fuelling future competition, security considerations).	☐	☐	☐	☐
I feel the technology was advanced but the training provided was not deep enough to be risky for the foreign company (e.g. risk of fuelling future competition, security considerations).	☐	☐	☐	☐
I feel the technology was advanced, but the foreign company considers the Algerian's capabilities are deemed to be not well enough advanced to make use of the advanced technology.	☐	☐	☐	☐

C. Activities after the project

42) Have you maintained relationships with the foreign firm personnel after the project? If yes, are these relationships informal or formal, a courtesy relationships or professional?

43) During your activities after this project, have you been involved in any satellite technology development?

- Describe your activities as part of other collaborative satellite projects with foreign companies (Alsat-2A, Alsat-2B, Alsta-1B, etc.)

- Describe your activities outside collaborative satellite projects (local activities, etc.)

44) As part of your satellite technology activities in Algeria, outside the collaborative projects (Alsat-2A, Alsat-2B, Alsat-1B), what were the aim and objectives of your activities?

45) How were the objectives defined? Who defined them?

45-a/ If the objectives were defined by you, were they discussed and agreed by other upper management levels? Which levels? Did they fit with other objectives?

-How clear do you find these objectives?

Circle the appropriate number

I find objectives clarity						
Low						High
	1	2	3	4	5	

-How complex do you find these objectives? Considering that complexity is a mix of: Number of developed/customised components required for achieving the objective, Number of skills (diversity) required for the project, and New knowledge required for the project.

Circle the appropriate number

I find objectives complexity						
Low						High
	1	2	3	4	5	

-How risky do you find these objectives?

Circle the appropriate number

I find objectives risk						
Low						High
	1	2	3	4	5	

-How flexible are these objectives in terms of specification (freedom to adjust specifications or to completely review objectives)?

Circle the appropriate number

I find objectives specification flexibility					
Low flexibility				High flexibility	
1	2	3	4	5	

-How flexible are these objectives in terms of funding (freedom to ask more money)?

Circle the appropriate number

I find objectives funding flexibility					
Low flexibility				High flexibility	
1	2	3	4	5	

-How flexible are these objectives in terms of time (freedom to go beyond timeline)?

Circle the appropriate number

I find objectives timeline flexibility					
Low flexibility				High flexibility	
1	2	3	4	5	

-In general, how ambitious do you find these objectives?

Circle the appropriate number

I find these objectives					
Not ambitious				Ambitious	
1	2	3	4	5	

-How do you report work progress related to these objectives? How often? to whom?

45-b/ If objectives were defined elsewhere, where exactly? Which management levels? Did they fit with other objectives?

-How clear do you find these objectives?

Circle the appropriate number

I find objectives clarity					
Low					High
1	2	3	4	5	

- How complex do you find these objectives? Considering that complexity is a mix of: Number of developed/customised components required for achieving the objective, Number of skills (diversity) required for the project, and New knowledge required for the project.

Circle the appropriate number

I find objectives complexity					
Low					High
1	2	3	4	5	

-How risky do you find these objectives?

Circle the appropriate number

I find objectives risk						
Low					High	
	1	2	3	4	5	

-How flexible are these objectives in term of specification (freedom to adjust specifications or to completely review objectives)?

Circle the appropriate number

I find objectives specification flexibility						
Low flexibility					High flexibility	
	1	2	3	4	5	

-How flexible are these objectives in term of funding (freedom to ask more money)?

Circle the appropriate number

I find objectives funding flexibility						
Low flexibility					High flexibility	
	1	2	3	4	5	

-How flexible are these objectives in term of time (freedom to go beyond timeline)?

Circle the appropriate number

I find objectives timeline flexibility						
Low flexibility					High flexibility	
	1	2	3	4	5	

-In general, how ambitious do you find these objectives?

Circle the appropriate number

I find these objectives						
Not ambitious					Ambitious	
	1	2	3	4	5	

-How do you report work progress related to these objectives? How often? to whom?

46) How often have you met (formally or informally) senior leaders from your organisation to discuss about these objectives during the period from the end of the project until now? Who were they? In which occasion? and what was the aim of the meeting?

47) How motivated were you in order to achieve these objectives?

Circle the appropriate number

My motivation was						
Low					High	
	1	2	3	4	5	

-Why, what motivated you the most, what motivated you the less?

48) Based on your experience on the component you specialised in during the project, how is the related technology evolving (rate of system development) and how different are the new systems (architecture, components) compared to the old ones and how different are the processes of their development? (Even/uneven, slow rate, fast, too fast, completely different, similar, etc.). Indicate changes for the case of Algerian satellites.

49) With regard to your activities in Algeria that are related to the component(s) you specialised in during the project, are you part of a larger team/project or your activity is rather individual?

49-a/ If you are part of a larger team/project

-What is the size of this team/project (number of personnel, specialisation, position, location, organisation, etc.)? Indicate if members were part of any collaborative satellite projects (with foreign firms) and indicate which projects?

-If this team involved more than one organisation, was this collaboration framed by explicit agreement between organisations or just informal collaboration? What is the core-competencies that you distinguish you or your organisation from the others?

-How would you describe relationship with the team/project members? Rate for each member, including the team leader

Circle the appropriate number for each member (including the team leader)

Team/project members	Intensity of relationship	Formality of relationships	Difficulty of relationships
	Non-intense (mild) — Very intense	Informal (not well defined, flexible) — Formal (well defined)	Easy and not conflicting — Difficult and conflicting
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Give further details if required:

49-b/ If your activity is rather individual, have you built your own network of individuals / specialists / academics (within or outside your organisation) that can contribute in your work? (number of personnel, specialisation, positions, organisations, etc.). Give examples

50) With regard to your activities in Algeria that are related to the component(s) you specialised in during the project,

- Have you benefited from a training that is related (or complements) to the knowledge you acquired during the project? (Indicate training that was provided outside other satellite collaborative projects)

- How easily do you participate in seminars and conferences that are related to the component you specialised in?

- How easily do you access to patent information related to the system you worked on it during the project?

51) With regard to your activities in Algeria that are related to the component(s) you specialised in during the project, have you trained, mentored, supervised people in your organisation? Give details on trainees, how many trainees? Why were they trained? How long the training lasted? What kind of training you provided?

52) Do you have in your organisation in Algeria any entity (department, laboratory, etc.) that is in charge of developing components on which you specialised? What is your relation to this entity?

53) Indicate your activities in Algeria that are related to, or make use of, the knowledge acquired on the component(s) you specialised in during the project?
Fill in the table considering that:
- “Research” refers to basic research
- “Development” refers to translating technical and scientific knowledge into products, processes, and services
- “Engineering” refers to very practical aspects

Activity categories	Examples and description (precise whether it is individual activity or team activity)
Research	
Development	
Engineering	
Teaching	
Other	

54) In your view, what would be the share of your activities related to the component(s) you specialised in, compared to all your activities in Algeria?

Circle the appropriate number

Activities related to the component(s) I specialised in represent						
Small share of my total activity in Algeria						Big share of my total activity in Algeria
	1	2	3	4	5	

55) In general, how do you find the nature of your activities in Algeria? Fill in the table considering that:
- “Research” refers to basic research
- “Development” refers to translating technical and scientific knowledge into products, processes, and services
- “Engineering” refers to very practical aspects

Activities	Proportions		Give examples, explanations and details
Administrative activities	…….%		
Scientific activities	…….%	………% Research	
		………% Development	
		………% Engineering	
		……..% Teaching	
Other	….%		

D. Final suggestions

56) Based on your experience on the component(s) you specialised in during the project, how reasonable would be the objective of developing similar or equivalent component(s) locally?

Circle the appropriate number for each component/function you specialised in

component(s) you specialised in	I find the objective of developing similar or equivalent component(s) locally
	Not reasonable objective ... Very reasonable objective
	1 2 3 4 5
	1 2 3 4 5
	1 2 3 4 5
	1 2 3 4 5

-Why? What would be the local effort and the foreign contribution?

57) Based on your experience on satellite technology, which of the following statement matches your view most closely in order to start developing similar or equivalent component locally?

Tick the appropriate box

	Disagree	Tend to disagree	Tend to agree	Agree
I would suggest to work with foreign firms on relatively old, less complex technology providing relatively modest or low system performances	☐	☐	☐	☐
I would suggest to work with foreign firms on relatively new, complex technology providing relatively high system performances	☐	☐	☐	☐
I would prefer to work **more often** on technology with higher risk of failure (non-completion of the project or system failure) rather than working **less often** on technology with lesser risk of failure	☐	☐	☐	☐

58) How averse to risk do you find your organisation when it comes to developing satellite component locally?

Circle the appropriate number

I find my organisation
Low risk averse ... High risk averse
1 2 3 4 5

-Why

59) How motivated are you right now in order to participate in developing similar or equivalent component locally?

Circle the appropriate number

My motivation is					
Low					High
1	2	3	4	5	

-Why?

60) How confident do you feel about your current abilities in order to participate in developing similar or equivalent component locally?

Circle the appropriate number

My confidence in my current abilities is					
Low					High
1	2	3	4	5	

-Why?

61) How satisfied are you with your career development in your organisation?

Circle the appropriate number

With regard to my career development, my satisfaction is					
Low					High
1	2	3	4	5	

-Why?

62) In general, how conducive do you find the environment within your organisation for your work and the development of your activities?

Circle the appropriate number

I find the environment in my organisation					
Not conducive					Very conducive
1	2	3	4	5	

-Why?

63) In general, how conducive do you find the national environment for your work and the development of your activities?

Circle the appropriate number

I find the national environment					
Not conducive					Very conducive
1	2	3	4	5	

-Why?

64) How confident do you feel about the process of building satellite system in Algeria?

Circle the appropriate number

With regard to building satellite system in Algeria, I feel					
Not confident					Very confident
1	2	3	4	5	

-Why?

Appendix 1-b: Questionnaires for team members (French version)

Date:	Participant ID:

Questions sur la mise en place de capacités de développement de petits satellites en Algérie

adressées aux membres de l'équipe du projet Alsat-1

Objectifs de le recherche: Recueillir des données qui permettent de mieux comprendre le processus de transfert des technologies satellitaires pour le cas de l'Algérie. Cela permettra aux Algériens d'avoir une appréciation sur l'efficacité des mécanismes qu'ils utilisent pour mettre en place un potentiel de développement des technologies de petits satellites, et fournira des indications sur les processus les plus efficaces à adopter pour transférer les technologies satellitaires.

Orientations pour répondre aux questions:

- Utilisez, à votre convenance, l'arabe, le français ou l'anglais au moment de répondre.
- Certaines réponses sont formulées en encerclant un nombre ① ou en cochant une case **√** , d'autres réponses exigent des commentaires écrits. Si l'espace prévu sur le formulaire est insuffisant pour vos commentaires, utilisez des feuilles supplémentaires. Vous pouvez également joindre des documents que vous estimeriez pertinents.
- Une fois que vous aurez répondu aux questions, le chercheur lui-même vous interviewera (face-à-face) lors d'une réunion, à convenir, pour s'assurer de la bonne compréhension des questions et de la bonne formulation des réponses.
- Toutes les réponses seront traitées de manière confidentielle. Seul le chercheur aura accès à ces réponses. Votre identité ne sera pas révélée. Vous serez identifié seulement par un code (ex. participant A, B, C, etc.).

Sections couvertes:

A. Informations générales
B. Activités dans le cadre du projet
C. Activités après le projet
D. Suggestions finales

A. Informations générales

1) Quelle est votre formation? Indiquez les institutions de formation et les périodes correspondantes (Indiquez à partir du «Baccalauréat»).

Formation/Diplôme	Période	Institution de formation

2) Quel est votre parcours professionnel? Indiquez les organisations (employeurs) et les périodes correspondantes.

Postes, Responsabilités professionnelles	Période	Organisations (employeurs)

3) Avant de participer à ce projet, aviez-vous déjà pris part à d'autres projets ou activités impliquant des étrangers (Exemple : projets conjoints, négociations, R&D conjoints, etc.)?

4) Quand aviez-vous rejoint l'équipe du projet? Pourquoi et comment aviez-vous été sélectionné pour le projet? Décrivez l'ensemble du processus.

5) Combien de temps avant le début du projet aviez-vous été informé de votre sélection?

6) Aviez-vous participé à des activités préparatoires liées au projet avant son début? (Par exemple: l'évaluation des technologies, négociation du projet avec la firme étrangère, des études de conception ou de spécification, des sessions d'initiation au projet, formation pratique, formation théorique, formation de langue, etc.). Expliquez quelles étaient ces activités? Comment elles étaient utiles pour le projet? Est-ce que leurs durées étaient appropriées ? Comment auraient-elles pu être effectuées pour un meilleur résultat?

7) Combien de fois aviez-vous rencontré (d'une manière formelle ou informelle) des hauts dirigeants de votre organisation avant le début du projet afin de discuter sur le projet? Qui étaient-ils? A quelle occasion et quel était le but des rencontres?

8) Quelle était votre motivation avant le début de ce projet?

Encerclez le nombre approprié

Le niveau de ma motivation était				
Bas				Haut
1	2	3	4	5

-Pourquoi? Qu'est-ce qui vous motivait le plus, qu'est-ce qui vous motivait le moins?

B. Activités dans le cadre du projet

9) Dans quel(s) composant (s) (par exemple: Unité/Module/Sous-système/Système) ou fonction (s) vous vous êtes spécialisés? Cochez la ou les cases appropriées. Donnez une indication sur la profondeur de votre implication dans les composants et les fonctions autres que celles dont vous vous êtes spécialisés.

composant (s) (par exemple: Unité/Module/Sous-système/Système) ou fonction (s)	Je me suis spécialisé dans ce/ces composant(s)	Mon implication dans ce / ces composants/fonctions était				
		Non profonde			Profonde	
Segment spatial (Space Segment)		1	2	3	4	5
Plate-forme (Platform)		1	2	3	4	5
Structure		1	2	3	4	5
Contrôle thermique (Thermal control)		1	2	3	4	5
Alimentation de bord (On-board power supply)		1	2	3	4	5
contrôle d'attitude (Attitude control)		1	2	3	4	5
Traitement des données (Data handling)		1	2	3	4	5
Charge utile (Payload)		1	2	3	4	5
Intégration, Assemblage et test (Integration-Assembly-Test)		1	2	3	4	5
Intégration plate-forme (Spacecraft Integration)		1	2	3	4	5
Intégration plate-forme avec charge utile (Payload-to-spacecraft Integration)		1	2	3	4	5
Test Satellite (Satellite Testing)		1	2	3	4	5
Equipement de servitude au Sol (Ground Support Equipment-GSE)		1	2	3	4	5
Segment Sol (Ground Segment)		1	2	3	4	5
Contrôle de mission (Mission Control)		1	2	3	4	5
Contrôle charge utile (Payload Control)		1	2	3	4	5
Système de communication (Communication System)		1	2	3	4	5
Fonctions de support (Support Functions)		1	2	3	4	5
Management (gestion du programme) - Management task (Programme Management)		1	2	3	4	5
ingénierie système - Engineering tasks (System Engineering)		1	2	3	4	5
Assurance de produit (Product assurance tasks)		1	2	3	4	5
Formation (Training)		1	2	3	4	5
Lancement, Exploitation et entretien (Launch, Operations and Maintenance)		1	2	3	4	5
Lancement (Launch)		1	2	3	4	5
Exploitation et entretien (Operations and Maintenance)		1	2	3	4	5
Autres						

10) Où et comment le composant dans lequel vous vous êtes spécialisés a été développé? (Conçu, manufacturé, intégré, testé, complètement par la firme dans ses installations, partiellement, etc.).

-Si le composant a été développé partiellement à l'extérieur de la firme, quelle a été votre niveau d'implication dans le développement extérieur (par exemple : en participant au développement, à la formation, dans des installations des fournisseurs/sous-traitant, aux réunions/échanges)? Décrivez comment la collaboration technique entre la firme (Prime) et ses fournisseurs/sous-traitants a été effectuée? Et quelle est la profondeur des connaissances de la firme (Prime) sur ce composant et pourquoi elle a eu recours à ces fournisseurs/sous-traitants?

11) En ce qui concerne les composants/fonctions dont vous vous êtes spécialisés, quel était votre rôle (obligations/missions/objectifs)?

composants/fonctions dont vous vous êtes spécialisés	Obligations/missions/objectifs

-Avez-vous trouvé vos connaissances préalables (formation/compétences/connaissances/expériences) appropriées aux exigences des composants/fonctions dont vous vous êtes spécialisés?

Encerclez le nombre approprié pour chaque composants/fonctions dont vous vous êtes spécialisés

composants/fonctions dont vous vous êtes spécialisés	Mes connaissances préalables étaient				
	Inferieures aux exigences		Proches des exigences		Au-delà des exigences
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5

-Pourquoi? et quelles sont les connaissances qui ont été les plus requises?

-Comment avez-vous trouvé la clarté des objectifs de votre participation au projet?

Encerclez le nombre approprié pour chaque composants/fonctions dont vous vous êtes spécialisés

composants/fonctions dont vous vous êtes spécialisés	J'ai trouvé les objectifs				
	Pas clairs				clairs
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5

-Pourquoi?

-Comment avez-vous trouvé l'ambition des objectifs de votre participation au projet?

Encerclez le nombre approprié pour chaque composants/fonctions dont vous vous êtes spécialisés

composants/fonctions dont vous vous êtes spécialisés	J'ai trouvé les objectifs				
	Pas ambitieux				Ambitieux
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5

-Pourquoi?
-Quel type de formation vous avez suivi durant le projet?

Remplissez les cellules et encerclez le nombre approprié pour chaque type de formation

<table>
<tr><th rowspan="3">Type de formation</th><th rowspan="3">Durée</th><th rowspan="3">Comment la formation a été contrôlée et supervisée (Evaluation académique, tests et examens, mémoires et dissertation, présentation, travaux pratiques, etc.)</th><th colspan="2">Est-ce que la formation a été appropriée pour le reste de vos activités</th></tr>
<tr><th>Durant le projet</th><th>Après le projet</th></tr>
<tr><th>Inappropriée Appropriée</th><th>Inappropriée Appropriée</th></tr>
<tr><td>Formation Théorique (Cours académiques, cours axés sur des projets, etc.)</td><td></td><td></td><td>1 2 3 4 5</td><td>1 2 3 4 5</td></tr>
<tr><td>Formation Pratique (Effectuées sur des systèmes non-réels, tels que des projets et tâches spécifiques, expériences, etc.)</td><td></td><td></td><td>1 2 3 4 5</td><td>1 2 3 4 5</td></tr>
<tr><td>Formation sur les systèmes Réels (On Job training) Travaux pratiques effectués sur des systèmes réels)</td><td></td><td></td><td>1 2 3 4 5</td><td>1 2 3 4 5</td></tr>
</table>

12) En ce qui concerne les composants/fonctions dont vous vous êtes spécialisés, Comment avez-vous trouvé la profondeur des connaissances acquises durant le projet?

Encerclez le nombre approprié pour chaque composants/fonctions dont vous vous êtes spécialisés

composants/fonctions dont vous vous êtes spécialisés	J'ai trouvé les connaissances Pas profondes Profondes
	1 2 3 4 5
	1 2 3 4 5
	1 2 3 4 5
	1 2 3 4 5

-Pourquoi? (Donnez des explications sur les disciplines requises et celles qui ont été couvertes, est ce que le temps passé durant les formations était suffisant? Est-ce que le nombre d'Algériens formés était suffisant? Est-ce que les connaissances transmises ont été axées sur les architectures, processus d'intégration, ou sur des aspects particuliers du composant dont vous vous êtes spécialisés, etc.? Quel serait le nombre approprié de stagiaires et les profils (background) appropriés pour une acquisition efficace des connaissances?

13) En ce qui concerne les composants/fonctions dont vous étiez seulement impliqués (et non spécialisés), Comment avez-vous trouvé la profondeur des connaissances acquises?

Encerclez le nombre approprié pour chaque composants/fonctions dont vous étiez impliqués (et non spécialisés)

composants/fonctions dont vous étiez impliqués (et non spécialisés)	J'ai trouvé les connaissances Pas profondes Profondes
	1 2 3 4 5
	1 2 3 4 5
	1 2 3 4 5
	1 2 3 4 5

-Comment et pourquoi?

14) Durant le projet, quelles sont les phases du projet dans lesquelles vous avez pris part ?

Phases de projet	Description des phases	Quelles étaient vos Missions/obligations/objectifs	Mon implication dans cette phase était				
			Pas profonde				Profonde
Phase 0	Analyse de mission / identification des besoins, où les objectifs et les fonctions de la mission sont définis (Mission analysis/needs identification, where mission aims and functions to be performed are defined)		1	2	3	4	5
Phase A	Faisabilité, où les concepts généraux de la mission et les exigences fonctionnelles du système sont définies (Feasibility, where mission general concepts and system functional requirements are defined)		1	2	3	4	5
Phase B	Définition préliminaire, où les exigences fonctionnelles des sous-systèmes sont définies, toutes les activités et les ressources pour le développement du projet sont identifiés, l'évaluation préliminaire des risques est effectuée (Preliminary Definition, where sub-systems functional requirements are defined, all activities and resources for the project development are identified, and preliminary risk assessment is carried out)		1	2	3	4	5
Phase C	Définition détaillée, lorsque les spécifications techniques et fonctionnelles détaillées des segments, spatial et sol, sont définis (Detailed Definition, where the detailed technical and functional specifications of the space and ground segments are defined)		1	2	3	4	5
Phase D	Fabrication, assemblage et essais, où le développement et la qualification du système (segment spatial et sol) et ses produits (images) sont réalisées (Manufacturing, Assembly and Testing, where the development and qualification of the system (space and ground segment) and its products (images) are carried out)		1	2	3	4	5
	- Approvisionnement (de service ou d'équipement, auprès des tiers). (Procurement (of service or equipment, from third-party))		1	2	3	4	5
	- Fabrication/Développement (soit au sein de l'entreprise ou à l'extérieur de l'entreprise) (Manufacturing/development (either within the firm or outside the firm))		1	2	3	4	5
	- Assemblage (Soit au sein de l'entreprise ou à l'extérieur de l'entreprise) (Assembly (either within the firm or outside the firm))		1	2	3	4	5
	- Tests ou essais (Soit au sein de l'entreprise ou à l'extérieur de l'entreprise) (Testing (either within the firm or outside the firm))		1	2	3	4	5
Phase E	Lancement et exploitation du système, où les activités liées au lancement, la mise en service, le maintien des éléments orbitaux du segment spatial en utilisant le segment sol sont effectuées (Launch and operations of the system, where activities related to launch, commissioning, maintaining space segment orbital elements and utilising ground segment are performed)		1	2	3	4	5
Phase F	Livraison, il s'agit des activités nécessaires pour mettre le système à la disposition du client (ou de l'opérateur). (Disposal, referring the activities needed to put the system at customer's (or operator's) disposal)		1	2	3	4	5
Autres							

Donnez plus de détails si nécessaire.

15) Décrivez les phases auxquelles vous avez participé?

Remplissez les cellules et encerclez le nombre approprié pour chaque phase

Phase à laquelle vous avez participé	Durée de votre participation (Jours/heures)	Quels types de formation ont été dispensés	Est-ce que le temps passé dans cette phase était suffisant pour acquérir efficacement les connaissances?	Est-ce que la formation a été appropriée pour vos activités	
				Durant le projet	Après le projet
			Insuffisant Suffisant	Inappropriée Appropriée	Inappropriée Appropriée
			1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
			1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
			1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
			1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
			1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
			1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
			1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Donnez plus de détails si nécessaire.

16) Durant le projet, quelles sont les réunions/revues dans lesquelles vous avez pris part ?

Encerclez le nombre approprié pour chaque réunion/revue

Réunions/Revues	Dans quelle mesure vous avez contribué dans ces réunions/revues	Dans quelle mesure vous avez appris de la contribution des autres participants?
	Je n'ai pas contribuée — J'ai Fortement contribué	Je n'ai pas appris beaucoup — J'ai beaucoup appris
Revue de Définition de Mission (Mission Definition Review-MDR)	1 2 3 4 5	1 2 3 4 5
Revue des Spécifications Préliminaires (Preliminary Requirements Review-PRR)	1 2 3 4 5	1 2 3 4 5
Revue des Spécifications Système (System Requirements Review-SRR)	1 2 3 4 5	1 2 3 4 5
Revue de Conception Préliminaire (Preliminary Design Review-PDR)	1 2 3 4 5	1 2 3 4 5
Revue de Conception Critique (Critical Design Review-CDR)	1 2 3 4 5	1 2 3 4 5
Revue de Qualification (Qualification Review-QR)	1 2 3 4 5	1 2 3 4 5
Revue d'Acceptation (Acceptance Review-AR)	1 2 3 4 5	1 2 3 4 5
Revue d'Aptitude Opérationnelle (Operational Readiness Review-ORR)	1 2 3 4 5	1 2 3 4 5
Revue d'Aptitude au Vol (Flight Readiness Review-FRR)	1 2 3 4 5	1 2 3 4 5
Revue d'Aptitude au Lancement (Launch Readiness Review-LRR)	1 2 3 4 5	1 2 3 4 5
Revue des Résultats de Mise en service (Commissioning Result Review-CRR)	1 2 3 4 5	1 2 3 4 5
Revue de Fin de Vie (End-of-life Review-ELR)	1 2 3 4 5	1 2 3 4 5
Revue de Clôture de la Mission (Mission Close-out Review-MCR)	1 2 3 4 5	1 2 3 4 5
Autres		

Donnez plus de détails si nécessaire.

17) Combien de fois aviez-vous rencontré (d'une manière formelle ou informelle) des hauts dirigeants de votre organisation au cours du projet afin de discuter sur le projet? Qui étaient-ils? A quelle occasion et quel était le but de ces rencontres?

18) Quelle est la fiabilité des composants dont vous vous êtes spécialisés?

Cochez la case appropriée pour chaque composant dont vous vous êtes spécialisés

composants dont vous vous êtes spécialisés	La fiabilité du composant était					
	inférieure à 70%	entre 70 et 80%	entre 80 et 90%	entre 90 et 95%	entre 95 et 99%	Supérieure à 99%
	☐	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐	☐

19) Quelle est la complexité des composants dont vous vous êtes spécialisés? Considérant que la complexité est une combinaison de: -Nombre de sous-composants à développer /personnaliser pour l'élaboration du composant, -Nombre de compétences (diversité) nécessaires, -Nouvelles connaissances nécessaires.

Encerclez le nombre approprié pour chaque composant dont vous vous êtes spécialisés

composants dont vous vous êtes spécialisés	La complexité du composant était				
	Ordinaire				Haute
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5

-Pourquoi?

20) Quelle est la performance des composants dont vous vous êtes spécialisés?

Encerclez le nombre approprié pour chaque composant dont vous vous êtes spécialisés

composants dont vous vous êtes spécialisés	La performance du composant était				
	Basse				Haute
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5

-Pourquoi?

21) Quelle est la part des COTS (Commercial off-the-shelf) dans les composants dont vous vous êtes spécialisés?

Encerclez le nombre approprié pour chaque composant dont vous vous êtes spécialisés

composants dont vous vous êtes spécialisés	La part des COTS était				
	Basse				Haute
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5

22) Quelle est la part des éléments matures dans les composants? (Par exemple : la technologie qui a un héritage établi dans l'utilisation dans l'espace, la technologie qui a des scores élevés sur les échelles Technology Readiness Level-TRL ou Manufacturing readiness level-MRL)

Encerclez le nombre approprié pour chaque composant dont vous vous êtes spécialisés

composants dont vous vous êtes spécialisés	La part des éléments matures était				
	Basse				Haute
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5

23) En ce qui concerne les composants dont vous vous êtes spécialisés, Comment trouviez-vous les connaissances fournies par la société étrangère au cours du projet, pour chacune des caractéristiques suivantes:

a/ En terme de Nouveauté (par rapport à la connaissance déjà disponible dans ce secteur)?

Encerclez le nombre approprié pour chaque composant dont vous vous êtes spécialisés

composants dont vous vous êtes spécialisés	Les connaissances fournies étaient
	Vielles Nouvelles
	1 2 3 4 5
	1 2 3 4 5
	1 2 3 4 5
	1 2 3 4 5

-Pourquoi?

b/ En terme d'ampleur (diversité des disciplines impliquées dans le composant dont vous vous êtes spécialisés)?

Encerclez le nombre approprié pour chaque composant dont vous vous êtes spécialisés

composants dont vous vous êtes spécialisés	Les connaissances fournies impliquent
	Peu de disciplines Beaucoup de disciplines
	1 2 3 4 5
	1 2 3 4 5
	1 2 3 4 5
	1 2 3 4 5

-Pourquoi?

c/ En terme de Profondeur (par rapport aux disciplines impliquées)?

Encerclez le nombre approprié pour chaque composant dont vous vous êtes spécialisés

composants dont vous vous êtes spécialisés	Les connaissances fournies étaient
	Pas très profondes Très profondes
	1 2 3 4 5
	1 2 3 4 5
	1 2 3 4 5
	1 2 3 4 5

-Pourquoi?

24) A votre avis, quelle est la complexité du système satellitaire en entier? Considérant que la complexité est une combinaison de: -Nombre de composants à développer /personnaliser pour l'élaboration du système satellitaire, -Nombre de compétences (diversité) nécessaires pour le projet satellitaire, -Nouvelles connaissances nécessaires pour le projet satellitaire.

Encerclez le nombre approprié

La complexité du système satellitaire était						
Ordinaire						Haute
	1	2	3	4	5	

-Pourquoi?

25) A votre avis, quelle est la performance du système satellitaire en entier ?

Encerclez le nombre approprié

La performance du système satellitaire était						
Basse						Haute
	1	2	3	4	5	

-Pourquoi?

26) Donnez la liste des outils d'ingénierie, équipements, logiciels et installations utilisés pour le développement des composants dont vous vous êtes spécialisés?

Phases	Les outils d'ingénierie, équipements, logiciels et installations		
	Utilisés par la compagnie étrangère	Que vous avez utilisé vous-même durant le projet	Qui sont disponibles dans vos installations en Algérie (ou peuvent être facilement trouvés ailleurs en Algérie)
Durant la spécification et la conception (specification and design)			
Durant l'approvisionnement (procurement)			
Durant le développement			
Durant l'Assemblage (Assembly)			
Durant l'intégration (integration)			
Durant les tests/essaie (test)			
Durant le lancement et l'exploitation (launch and operations)			
Autres			

-Si les outils d'ingénierie, équipements, logiciels et installations nécessaires pour le développement des composants dont vous vous êtes spécialisés ne sont pas disponibles (ou manquant) dans vos installations en Algérie? A quel point ils sont importants ? et peuvent-ils être achetées ou acquis ?

27) Donnez la liste de la documentation et des ressources documentaires utilisées pour le développement des composants dont vous vous êtes spécialisés?

Phases	La documentation et les ressources documentaires		
	Utilisées par la compagnie étrangère	Que vous avez utilisé vous-même durant le projet	Qui sont disponibles dans vos installations en Algérie (ou peuvent être facilement trouvées ailleurs en Algérie)
Durant la spécification et la conception (specification and design)			
Durant l'approvisionnement (procurement)			
Durant le développement			
Durant l'Assemblage (Assembly)			
Durant l'intégration (integration)			
Durant les tests/essaie (test)			
Durant le lancement et l'exploitation (launch and operations)			
Autres			

-Si la documentation et les ressources documentaires nécessaires pour le développement des composants/fonctions dont vous vous êtes spécialisés ne sont pas disponibles (ou manquant) dans vos installations en Algérie? A quel point elles sont importantes ? Pourquoi elles n'ont pas pu être achetées ou acquises? Avez-vous essayé de les reproduire (même en partie)?

-En ce qui concerne la documentation du projet et les ressources documentaires ramenées en Algérie, Comment sont-elles gérées? Où sont-elles? Est-ce qu'elles sont facilement accessibles? Qui a accès à elles? Est-ce que cette documentation a été utilisée depuis lors?

28) En se basant sur les connaissances acquises au cours du projet (soit à travers des ressources écrites ou non écrites), avez-vous tenté de préparer une documentation (ex. documentation théorique, documentation pratique, rapport/routines/tests/procédures, etc.) pour un usage interne au sein de votre organisation en Algérie? Et quelle est l'importance de cette documentation pour effectuer indépendamment des tâches en Algérie?

29) En se basant sur les connaissances acquises au cours du projet (soit à travers des ressources écrites ou non écrites), avez-vous tenté de mener une activité de R&D, publiée ou non publiée, (ex. articles de revues, conférences, rapports d'études, brevets, etc.)? Combien de travaux ont été menés? Quelles sont les personnes impliquées et quelles sont leurs organisations/institutions d'appartenance?

30) Donnez la liste des ressources humaines et compétences nécessaires pour le développement des composants dont vous vous êtes spécialisés?

Phases	Les ressources humaines et compétences	
	Utilisées par la compagnie étrangère	Qui sont disponibles dans vos installations en Algérie (ou peuvent être facilement trouvées ailleurs en Algérie)
Durant la spécification et la conception (specification and design)		
Durant l'approvisionnement (procurement)		
Durant le développement		
Durant l'Assemblage (Assembly)		
Durant l'intégration (integration)		
Durant les tests/essaie (test)		
Durant le lancement et l'exploitation (launch and operations)		
Autres		

-Si les ressources humaines et compétences nécessaires pour le développement des composants/fonctions dont vous vous êtes spécialisés ne sont pas disponibles (ou manquant) dans vos installations en Algérie? A quel point elles sont importantes ? A quel point il est difficile de les former ou de les recruter ?

31) Quelle était la langue (ou les langues) de travail durant le projet? Etiez-vous à l'aise avec cette langue (ou ces langues)?

Encerclez le nombre approprié pour chaque langue utilisée durant le projet

Langue(s)	J'étais
	Moins à l'aise Très à l'aise
	1 2 3 4 5
	1 2 3 4 5
	1 2 3 4 5

32) Durant votre participation au projet, combien de mentors (superviseurs) aviez-vous ? et combien de temps aviez-vous passé sous leur mentorat (supervision)?

Mentor (superviseur)	Temps passé avec le mentor (superviseur)

33) Comment qualifiez-vous votre relation de travail avec vos mentors durant le projet?

Encerclez le nombre approprié pour chacun des mentors durant le projet

Mentor (s)	Intensité des relations	Formalité des relations	Difficulté des relations
	Non-intenses (légères) … très intenses	Informelles (pas bien définies, flexibles) … Formelles (bien définies)	Faciles et pas conflictuelles … Difficiles et conflictuelles
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

-Donnez plus de détails si nécessaire: (ex. il ne pouvait pas fournir plus de connaissances et d'information en raison des restrictions appliquées par son entreprise, la protection de la technologie, les termes contractuels ne prévoyaient pas cela, les deux personnalités étaient différentes ce qui rendait la communication difficile, etc.)

34) Comment qualifiez-vous les connaissances et les capacités pédagogiques de vos mentors?

Encerclez le nombre approprié pour chacun des mentors durant le projet

Mentor	Connaissances théoriques du mentor	Connaissances pratiques du mentor	Capacités pédagogiques
	Limitées … Etendues	Limitées … Etendues	Limitées … Hautes
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

-Donnez plus de détails si nécessaire, et donnez une indication sur le volume des connaissances que vous avez acquises de lui et pourquoi vous ne pouviez pas acquérir tout (ex. il a des connaissances limitées, il manque de communication, la langue (ou langage) qu'il utilisait était difficile à comprendre, les connaissances transmises n'étaient pas assez détaillées, les connaissances transmises ne pouvaient pas être facilement expliquées, les connaissances ont été transmises en utilisant des codes, symboles, frameworks inhabituels, le temps passé avec lui n'était pas suffisant, vos connaissances initiales sur la question étaient limitées et il était nécessaire, en premier, de mettre à jour les connaissances, puis suivre avec lui, etc.)

35) Quand, à quelle fréquence et à qui aviez-vous l'habitude de rapporter (et donner des feedbacks) sur l'avancement des travaux durant le projet? (Au mentor, au chef de projet algérien, est-ce que cela était fait régulièrement, occasionnellement lorsque la situation était jugée inacceptable, de façon formelle, de façon informelle, etc.?) Aviez-vous vécu des situations où vous avez soulevé des questions/problèmes? Aviez-vous une autonomie pour régler ces questions/problèmes?

36) Comment qualifiez-vous votre relation de travail durant le projet avec des collègues travaillant sur les mêmes composants dont vous vous êtes spécialisés?

Encerclez le nombre approprié pour chaque collègue travaillant sur le même composant

collègues	Intensité des relations	Formalité des relations	Difficulté des relations
	Non-intenses (légères) — très intenses	Informelles (pas bien définies, flexibles) — Formelles (bien définies)	Faciles et pas conflictuelles — Difficiles et conflictuelles
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

-Donnez plus de détails si nécessaire.

37) Comment qualifiez-vous votre relation de travail durant le projet avec des collègues travaillant sur d'autres composants/fonctions du système satellitaire (et pas les composants dont vous vous êtes spécialisés)?

Encerclez le nombre approprié pour chaque collègue travaillant sur d'autres composants/fonctions du système satellitaire (ex. chef de projet, ingénierie système, AIT, Energie, Charge utile, etc.)

collègues	Intensité des relations	Formalité des relations	Difficulté des relations
	Non-intenses (légères) — très intenses	Informelles (pas bien définies, flexibles) — Formelles (bien définies)	Faciles et pas conflictuelles — Difficiles et conflictuelles
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

-Donnez plus de détails si nécessaire.

38) Décrivez comment vous aviez été impliqué dans des tâches liées à l'intégration de l'ensemble du système satellitaire?

-Quelle était la profondeur de votre implication?

Encerclez le nombre approprié

Mon implication dans l'intégration de l'ensemble du satellite était
Pas profonde — Très profonde
1 2 3 4 5

39) Veuillez classer de "1" à "5" les sources de connaissances suivantes en fonction de leur contribution dans l'ensemble des connaissances que vous avez acquises durant le projet?
Exemple : "1" étant la source qui contribue le plus dans les connaissances acquises durant le projet.

Sources de connaissances	classement	Donnez des détails si nécessaire.
Mentor (s) (son jugement et appréciation)		
D'autres individus et experts (leurs jugements et appréciations)		
la documentation et les bases de données du projet (plans, manuels, guides, exigences système, spécifications, interfaces, plans et procédures d'implémentation, routines de test, rapports, etc.) (Blueprints, handbooks, workbooks, guides, system requirements, specifications, interfaces, implementation plans and procedures, test routines, reports, etc.)		
Bibliothèques (livres, publications et revues spécialisées, etc.)		
Autres		

40) Sur la base de votre expérience, laquelle des déclarations suivantes correspond le plus à votre point de vue sur l'orientation des connaissances que vous avez acquises durant le projet?

Cochez la case appropriée

	Je suis en désaccord	Plutôt en désaccord	Plutôt en accord	Je suis en accord
Les connaissances fournies ont été axées sur le composant dont vous vous êtes spécialisés en tant que composant indépendant	☐	☐	☐	☐
Les connaissances fournies ont été axées sur le composant dont vous vous êtes spécialisés en tant qu'élément appartenant à l'ensemble du système satellitaire (ex. l'interaction avec d'autres composants, processus d'intégration au sein de l'ensemble du système, etc.)	☐	☐	☐	☐

41) Sur la base de votre expérience, laquelle des déclarations suivantes correspond le plus à votre point de vue sur le risque pris par la compagnie étrangère lorsqu'elle dispensait des formations sur les composants dont vous vous êtes spécialisés?

Cochez la case appropriée

	Je suis en désaccord	Plutôt en désaccord	Plutôt en accord	Je suis en accord
Je crois que la formation dispensée était sur une technologie qui a été exploitée jusqu'à ses limites et peut être transférée sans risque (ex. risque d'alimenter une concurrence future, considérations sécuritaires).	☐	☐	☐	☐
Je crois que la technologie était avancée, mais la formation dispensée n'était pas assez profonde pour constituer un risque pour la société étrangère (ex. risque d'alimenter une concurrence future, considérations sécuritaires).	☐	☐	☐	☐
Je crois que la technologie était avancée, mais la société étrangère considérait que les capacités algériennes n'étaient pas assez avancées pour faire usage d'une technologie avancée.	☐	☐	☐	☐

C. Activités après le projet

42) Avez-vous entretenu des relations avec le personnel de la compagnie étrangère après le projet? Si oui, est-ce que ces relations sont formelles ou informelles, de courtoisie ou professionnelles?

43) Au cours de vos activités après ce projet, avez-vous été impliqué dans des développements de technologie satellitaire?

- Décrivez vos activités dans le cadre d'autres projets satellitaires avec des firmes étrangères (Alsat-2A, Alsat-2B, Alsat-1B, etc.)

- Décrivez vos activités en dehors des projets satellitaires avec des compagnies étrangères (activités locales, etc.)

44) Dans le cadre de vos activités liées aux technologies satellitaires en Algérie, en dehors des projets (Alsat-2A, Alsat-2B, Alsat-1B), quels étaient les buts et objectifs de vos activités?

45) Comment les objectifs ont été définis? Qui les a définis?

45-a/ Si les objectifs ont été définis par vous, est-ce qu'ils ont été discutés et approuvés par d'autres niveaux supérieurs de management? Quels sont ces niveaux? Est-ce que ces objectifs se complémentent avec d'autres objectifs?

-Comment avez-vous trouvé la clarté de ces objectifs?

Encerclez le nombre approprié

J'ai trouvé les objectifs						
Pas clairs						clairs
	1	2	3	4	5	

- Comment avez-vous trouvé la complexité de ces objectifs ? Considérant que la complexité est une combinaison de: -Nombre de composants à développer/personnaliser pour atteindre l'objectif, -Nombre de compétences (diversité) nécessaires pour le projet, -Nouvelles connaissances nécessaires pour le projet.

Encerclez le nombre approprié

La complexité des objectifs est						
Basse						Haute
	1	2	3	4	5	

- Comment avez-vous trouvé le risque associé à ces objectifs?

Encerclez le nombre approprié

Le risque associé aux objectifs est						
Bas						Haut
	1	2	3	4	5	

-Est-ce que ces objectifs sont flexibles en termes de spécifications (liberté d'ajuster les spécifications ou de revoir complètement les objectifs)?

Encerclez le nombre approprié

La flexibilité des objectifs en termes de spécifications est						
Basse (flexibilité)						Haute (flexibilité)
	1	2	3	4	5	

-Est-ce que ces objectifs sont flexibles en termes de financement (liberté de demander plus d'argent)?

Encerclez le nombre approprié

La flexibilité des objectifs en termes de financement est						
Basse (flexibilité)						Haute (flexibilité)
	1	2	3	4	5	

-Est-ce que ces objectifs sont flexibles en termes de délais (liberté d'aller au-delà des délais)?

Encerclez le nombre approprié

La flexibilité des objectifs en termes de délais est						
Basse (flexibilité)						Haute (flexibilité)
	1	2	3	4	5	

-En général, comment avez-vous trouvé l'ambition de ces objectifs ?

Encerclez le nombre approprié

J'ai trouvé les objectifs				
Pas ambitieux				Ambitieux
1	2	3	4	5

-Comment avez-vous l'habitude de rapporter (et donner des feedbacks) sur les travaux relatifs à ces objectifs? À quelle fréquence? à qui?

45-b/ Si les objectifs sont définis ailleurs, où exactement? A quel niveau de management? Est-ce que ces objectifs se complémentent avec d'autres objectifs?

-Comment avez-vous trouvé la clarté de ces objectifs?

Encerclez le nombre approprié

J'ai trouvé les objectifs				
Pas clairs				clairs
1	2	3	4	5

- Comment avez-vous trouvé la complexité de ces objectifs ? Considérant que la complexité est une combinaison de: -Nombre de composants à développer/personnaliser pour atteindre l'objectif, -Nombre de compétences (diversité) nécessaires pour le projet, -Nouvelles connaissances nécessaires pour le projet.

Encerclez le nombre approprié

La complexité des objectifs est				
Basse				Haute
1	2	3	4	5

- Comment avez-vous trouvé le risque associé à ces objectifs?

Encerclez le nombre approprié

Le risque associé aux objectifs est				
Bas				Haut
1	2	3	4	5

-Est-ce que ces objectifs sont flexibles en termes de spécifications (liberté d'ajuster les spécifications ou de revoir complètement les objectifs)?

Encerclez le nombre approprié

La flexibilité des objectifs en termes de spécifications est				
Basse (flexibilité)				Haute (flexibilité)
1	2	3	4	5

-Est-ce que ces objectifs sont flexibles en termes de financement (liberté de demander plus d'argent)?

Encerclez le nombre approprié

La flexibilité des objectifs en termes de financement est				
Basse (flexibilité)				Haute (flexibilité)
1	2	3	4	5

-Est-ce que ces objectifs sont flexibles en termes de délais (liberté d'aller au-delà des délais)?

Encerclez le nombre approprié

La flexibilité des objectifs en termes de délais est				
Basse (flexibilité)				Haute (flexibilité)
1	2	3	4	5

-En général, comment avez-vous trouvé l'ambition de ces objectifs ?

Encerclez le nombre approprié

J'ai trouvé les objectifs				
Pas ambitieux				Ambitieux
1	2	3	4	5

-Comment avez-vous l'habitude de rapporter (et donner des feedbacks) sur les travaux relatifs à ces objectifs? À quelle fréquence? à qui?

46) Combien de fois avez-vous rencontré (d'une manière formelle ou informelle) des hauts dirigeants de votre organisation afin de discuter sur ces objectifs? Qui étaient-ils? A quelle occasion et quel était le but des rencontres?

47) Quelle était votre motivation pour la réalisation de ces objectifs?

Encerclez le nombre approprié

Le niveau de ma motivation était				
Bas				Haut
1	2	3	4	5

-Pourquoi? Qu'est-ce qui vous motivait le plus, qu'est-ce qui vous motivait le moins?

48) En se basant sur votre expérience sur les composants dont vous vous êtes spécialisés, comment la technologie évolue (vitesse de développement du système) et quelles sont les similitudes/différences entre les nouveaux systèmes (architecture, composants) par rapport aux anciens, et quelles sont les similitudes/différences dans leurs processus de développement? (réguliers/irréguliers, vitesse lente, vitesse élevée, trop élevée, des systèmes complètement différents, systèmes similaires, etc.). Donnez des indications sur les changements pour le cas des satellites algériens.

49) En ce qui concerne vos activités en Algérie qui sont liées aux composants dont vous vous êtes spécialisés durant le projet, est-ce que vous faite partie d'une équipe/projet ou votre activité est plutôt individuelle?

49-a/ Si vous faite partie d'une équipe/projet,

-Quelle est la taille de cette équipe/projet (nombre de personnel, spécialisation, leurs postes/positions, emplacement, leurs organisations/institutions, etc.)? Indiquez si les membres faisaient partie des projets satellitaires et indiquez lesquels?

-Si cette équipe implique plus d'une organisation/institution, est-ce que cette collaboration est encadrée par un accord explicite entre organisations ou bien elle est informelle? Quelles sont les compétences clés qui distinguent votre organisation des autres?

-Comment qualifiez-vous votre relation de travail avec les membres de l'équipe/projet? Evaluez pour chaque membre, y compris le chef d'équipe

Encerclez le nombre approprié pour chaque membre y compris le chef d'équipe

Membres de l'équipe /projet	Intensité des relations	Formalité des relations	Difficulté des relations
	Non-intenses (légères) très intenses	Informelles (pas bien définies, flexibles) Formelles (bien définies)	Faciles et pas conflictuelles Difficiles et conflictuelles
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

-Donnez plus de détails si nécessaire

49-b/ Si votre activité est plutôt individuelle, avez-vous construit votre propre réseau d'individus / spécialistes / universitaires (à l'intérieur ou l'extérieur de votre organisation) qui peuvent contribuer dans votre travail? (Nombre de personnes, spécialisation, positions/postes, organisations, etc.). Donnez des exemples.

50) En ce qui concerne vos activités en Algérie liées aux composants dont vous vous-êtes spécialisés durant le projet,

-Avez-vous bénéficié d'une formation qui est liée aux connaissances acquises durant le projet (ou les complète)? (Indiquez les formations en dehors de celles prévues dans le cadre des autres projets satellitaires)

-Est-ce que vous participez facilement à des séminaires et conférences liées aux composants dont vous vous êtes spécialisés?

- Est-ce que vous accédez facilement aux informations sur les brevets liés aux systèmes sur lesquels vous avez travaillé durant le projet?

51) En ce qui concerne vos activités en Algérie liées aux composants dont vous vous êtes spécialisés durant le projet, avez-vous formé, encadré, supervisé des gens dans votre organisation? Donnez des détails sur les stagiaires, combien de stagiaires? Pourquoi ils ont été formés? Combien de temps a duré la formation? Quel type de formation a été dispensé?

52) Avez-vous dans votre organisation en Algérie une entité (département, laboratoire, etc.) en charge du développement des composants sur lesquels vous vous êtes spécialisés? Quelle est votre relation avec cette entité?

53) Indiquez vos activités en Algérie qui sont liées à, ou utilisent, des connaissances acquises durant le projet sur les composants dont vous vous êtes spécialisés? Remplissez le tableau en considérant que:
- "Recherche" fait référence à la recherche fondamentale
- "Développement" fait référence à la traduction de connaissances techniques et scientifiques en produits, procédés et services
- "Engineering" fait référence à des aspects très pratiques

Catégories des activités	Exemples et description (précisez s'il s'agit d'une activité individuelle ou en équipe)
Recherche	
Développement	
Engineering	
Enseignement	
Autres	

54) Selon vous, quelle serait la part de vos activités liées aux composants dont vous vous êtes spécialisés, par rapport à toutes vos activités en Algérie?

Encerclez le nombre approprié

<table>
<tr><td colspan="5">Les activités liées aux composants dont je me suis spécialisé représentent</td></tr>
<tr><td colspan="3">une petite part du total de mes activités en Algérie</td><td colspan="2">une grande part du total de mes activités en Algérie</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
</table>

55) En général, comment vous trouvé la nature de vos activités en Algérie? Remplissez le tableau en considérant que:
- "Recherche" fait référence à la recherche fondamentale
- "Développement" fait référence à la traduction de connaissances techniques et scientifiques en produits, procédés et services
- "Engineering" fait référence à des aspects très pratiques

<table>
<tr><th>Activités</th><th colspan="2">Proportions</th><th>Donnez des exemples, explications et détails</th></tr>
<tr><td>Activités administratives</td><td colspan="2">…….%</td><td></td></tr>
<tr><td rowspan="4">Activités scientifiques</td><td rowspan="4">…….%</td><td>………% Recherche</td><td></td></tr>
<tr><td>………% Développent</td><td></td></tr>
<tr><td>………% Engineering</td><td></td></tr>
<tr><td>……..% Enseignement</td><td></td></tr>
<tr><td>Autres</td><td colspan="2">….%</td><td></td></tr>
</table>

D. Suggestions finales

56) Selon votre expérience sur les composants dont vous vous êtes spécialisés durant le projet, est-ce que l'objectif de développer des composants similaires ou équivalents au niveau local serait raisonnable?

Encerclez le nombre approprié pour chaque composant dont vous vous êtes spécialisés

composants dont vous vous êtes spécialisés	Je trouve l'objectif de développer des composants similaires ou équivalents au niveau local
	Non raisonnable — Très raisonnable
	1 2 3 4 5
	1 2 3 4 5
	1 2 3 4 5
	1 2 3 4 5

-Pourquoi? Quels seraient l'effort local et la contribution de l'étranger?

57) Sur la base de votre expérience dans les technologies satellitaires, laquelle des déclarations suivantes correspond le plus à votre point de vue sur le début de développement de composants similaires ou équivalents au niveau local?

Cochez la case appropriée

	Je suis en désaccord	Plutôt en désaccord	Plutôt en accord	Je suis en accord
Je suggère de travailler avec des entreprises étrangères sur des technologies relativement anciennes, moins complexe, offrant des performances système relativement modestes ou faibles	☐	☐	☐	☐
Je suggère de travailler avec des entreprises étrangères sur des technologies relativement nouvelles, complexe, offrant des performances système relativement élevées	☐	☐	☐	☐
Je préférerais travailler **plus souvent** sur des technologies avec un risque d'échec plus élevé (non-achèvement de projet ou défaillance du système) plutôt que de travailler **moins souvent** sur des technologies avec un risque d'échec moindre	☐	☐	☐	☐

58) Selon vous, est-ce que votre organisation est favorable à prendre des risques lorsqu'il s'agit de développer des composants de satellites au niveau local?

Encerclez le nombre approprié

Je trouve que mon organisation est plutôt
favorable à prendre des risques — Non favorable à prendre des risques
1 2 3 4 5

-Pourquoi ?

59) Quelle est votre motivation actuelle pour prendre part au développement de composants similaires ou équivalents au niveau local?

Encerclez le nombre approprié

Le niveau de ma motivation est
Bas — Haut
1 2 3 4 5

-Pourquoi?

60) Est-ce que vous êtes confiant de vos aptitudes actuelles pour prendre part au développement de composants similaires ou équivalents au niveau local?

Encerclez le nombre approprié

Ma confiance dans mes capacités actuelle est				
Basse				Haute
1	2	3	4	5

-Pourquoi?

61) Êtes-vous satisfait de votre parcours professionnel (développement de carrière) dans votre organisation?

Encerclez le nombre approprié

S'agissant du développement de ma carrière, ma satisfaction est				
Basse				Haute
1	2	3	4	5

-Pourquoi?

62) En général, comment trouvez-vous l'environnement au sein de votre organisation pour votre travail et le développement de vos activités?

Encerclez le nombre approprié

Je trouve l'environnement au sein de mon organisation				
Non favorable				Très favorable
1	2	3	4	5

-Pourquoi?

63) En général, comment trouvez-vous l'environnement national pour votre travail et le développement de vos activités?

Encerclez le nombre approprié

Je trouve l'environnement national				
Non favorable				Très favorable
1	2	3	4	5

-Pourquoi?

64) Est-ce que vous êtes confiant du processus de développement de petits satellites en Algérie?

Encerclez le nombre approprié

S'agissant du développement local, ma confiance est				
Basse				Haute
1	2	3	4	5

-Pourquoi?

Appendix 1-c: List of participants in the study

#	Participant name	Position	Participant ID
1	/	/	ID-1
2	/	/	ID-2
3	/	/	ID-3
4	/	/	ID-4
5	/	/	ID-5
6	/	/	ID-6
7	/	/	ID-7
8	/	/	ID-8
9	/	/	ID-9
10	/	/	ID-10
11	/	/	ID-11
12	/	/	ID-12
13	/	/	ID-13
14	/	/	ID-14
15	/	/	ID-15
16	/	/	ID-16
17	/	/	ID-17
18	/	/	ID-18
19	/	/	ID-19
20	/	/	ID-20
21	/	/	ID-21
22	/	/	ID-22
23	/	/	ID-23
24	/	/	ID-24

25	/	/	ID-25
26	/	/	ID-26
27	/	/	ID-27
28	/	/	ID-28
29	/	/	ID-29
30	/	/	ID-30
31	/	/	ID-31
32	/	/	ID-32
33	/	/	ID-33
34	/	/	ID-34
35	/	/	ID-35
36	/	/	ID-36
37	/	/	ID-37
38	/	/	ID-38
39	/	/	ID-39
40	/	/	ID-40
41	/	/	ID-41
42	/	/	ID-42
43	/	/	ID-43
44	/	/	ID-44
45	/	/	ID-45
46	/	/	ID-46
47	/	/	ID-47
48	/	/	ID-48

Appendix 1-d: Questionnaires for project managers (English version)

Date:

Participant ID:

Questions on building small satellite capabilities in Algeria

addressed to Alsat-1 project manager

Research aim: Collection of data in order to gain better understanding of satellite technology transfer to Algeria. This will enable Algerians to gain an appreciation on the effectiveness of the mechanisms that they have used to build satellite technological capabilities, and will provide guidance regarding effective processes for transferring satellite technology.

Guidance in responding to questions:

- Please feel free to use Arabic, French or English when responding.
- Some responses require circling a number ① or ticking a box √ , some other responses require written comments. If the space provided on the form is insufficient for your comments, use additional sheets as required. Feel free to include any additional material deemed relevant.
- Once you have responded to questions, the researcher will be interviewing you by himself in a face-to-face meeting to ensure proper understanding of questions and responses.
- All responses will be treated as confidential with only the researcher having access to them. Your identity will not be revealed and you will remain anonymous. You will be only identified as Participant A, B, C, etc.

Sections covered:

A. General information
B. Activities as part of the project
C. Activities after the project
D. Final suggestions

A. General Information

1) What is your educational background? Indicate the corresponding educational organisations and time frame (Please indicate from the "Baccalauréat").

Education/Degree	Time frame	Educational organisations

2) What is your professional background? Indicate the corresponding organisation and time frame.

Positions/ Professional responsibilities	Time frame	Organisations

3) Before you participated in this project, have you ever participated in any project or activity involving foreigners (e.g. joint project, negotiations, joint R&D, etc.)?

4) Before you participated in this project, have you been trained on, or practiced, project management tools?

5) Before you participated in this project, have you been trained on satellite technology?

6) When did you join the satellite project team? Why and how were you selected for the project? Describe the entire process.

7) How long before the beginning of the project were you informed of your selection and of your appointment as team leader or project manager?

8) Did you participate in the selection of your team members? If Yes, to what extent?

9) Did you participate in any preparatory activity related to the project before its beginning? (For example: project management training, technology assessment, project negotiation with the firm, design or specification study, introductory sessions, practical training, theoretical training, language training, etc.). Explain what were these activities? How useful were they? How appropriate were their durations? How would have they been performed for better result?

10) How often did you meet (formally or informally) senior leaders from your organisation before the beginning of the project in order to discuss about the project? Who were they? In which occasion and what was the aim of the meeting?

11) How motivated were you before the beginning of this project?

Circle the appropriate number

My motivation was				
Low				High
1	2	3	4	5

-Why? What motivated you most, what motivated you less?

12) How motivated did you find your team members before the beginning of this project?

Circle the appropriate number

Their motivation was				
Low				High
1	2	3	4	5

-In your view, what motivated them most, what motivated them less?

B. Activities as part of the project

13) What was your team size? Describe your management chart and indicate areas of specialisation by individual?

14) What were the satellite component(s) (e.g. unit/module/sub-system/system) or function(s) you managed as part of your duties? Tick the appropriate box or boxes. Indicate how deep were you involved in the management of these components and functions? Number of your team members involved? Number of Algerian individuals, other than your team members, involved?

component(s) (e.g. unit/module/sub-system/system) or function(s)	My involvement in the management was					Number of my team members involved	Number of Algerians, other than my team members, involved
	Not deep				Deep		
Space Segment	1	2	3	4	5		
Platform	1	2	3	4	5		
Structure	1	2	3	4	5		
Thermal control	1	2	3	4	5		
On-board power supply	1	2	3	4	5		
Attitude control	1	2	3	4	5		
Data handling	1	2	3	4	5		
Payload	1	2	3	4	5		
Integration, Assembly, and Test	1	2	3	4	5		
Spacecraft Integration	1	2	3	4	5		
Payload-to-spacecraft Integration	1	2	3	4	5		
Satellite Testing	1	2	3	4	5		
Ground Support Equipment-GSE	1	2	3	4	5		
Ground Segment	1	2	3	4	5		
Mission Control	1	2	3	4	5		
Payload Control	1	2	3	4	5		
Communication System	1	2	3	4	5		
Support Functions	1	2	3	4	5		
Management task (Programme Management)	1	2	3	4	5		
Engineering tasks (System Engineering)	1	2	3	4	5		
Product assurance tasks	1	2	3	4	5		
Training	1	2	3	4	5		
Launch, Operations and Maintenance	1	2	3	4	5		
Launch	1	2	3	4	5		
Operations and Maintenance	1	2	3	4	5		
Other							

15) Where and how was the satellite system developed? (Designed, built, integrated, tested, completely by the firm within its facilities, or partially, etc.).

-If the satellite development was partially outsourced (developed outside the firm), what are components that have been outsourced? How deep was the knowledge of the Prime about the component and why did it rely on the supplier/subcontractor? Describe how was the collaboration between the Prime and the Suppliers/Subcontractor carried out?

- If the satellite development was partially outsourced, to what extent were you involved to the management of the outside development (e.g. participating in the development management, or trained on managing outsourced development, within the suppliers/subcontractor's facilities, meetings/exchange)?

16) The customer project manager in satellite collaborative project might have multiple roles when partaking in the project, so:

-What was your role (duties/mission/objectives) as the project customer representative (e.g. ensure the contract performance, negotiations with foreign firms representatives, etc.)?

-What was your role (duties/mission/objectives) as team leader (e.g. motivating the team, providing guidance, encouraging and facilitating communication development, and coordinating)?

-What was your role (duties/mission/objectives) as management skills learner or trainee (e.g. participating in training session on management tools, etc.)? Have you been trained on management tools and techniques (project structure, system of monitoring of schedules and budget, supply management, quality management, etc.)? Have you used these tools? Have your team members used these tools?

-What was your role (duties/mission/objectives) as engineer or technical leader? (e.g. if you participated in technical activities)

-What would be the proportions of tasks during your participation in the project?

Role (or tasks nature)	Proportions (%)
Project customer representative	……….%
Algerian team leader	……….%
Management skills learner	……….%
Engineer or technical leader	……….%
Other:	

17) In your view, what are the functions that are critical for satellite project management?

18) With regard to tasks requiring satellite management skills, how appropriate did you find your prior knowledge (background/skills/knowledge/profiles) to the requirements?

Circle the appropriate number

My prior knowledge was		
Less than requirement	close to requirement	beyond requirement
1 2	3	4 5

-Why? and what was the most needed knowledge?

19) How clear did you find the objectives of your participation in the project?

Circle the appropriate number

I found the objectives		
Not clear		clear
1 2	3	4 5

-Why?

-In your view, which of the following statement matches your view most closely on the priority in this project?

Tick the appropriate box

	Disagree	Tend to disagree	Tend to agree	Agree
The priority of this project was the acquisition of a satellite system and its deployment	☐	☐	☐	☐
The priority of this project was learning how to develop a satellite system	☐	☐	☐	☐

20) How ambitious did you find the objectives of your participation in the project?

Circle the appropriate number

I found the objectives				
Not ambitious				Ambitious
1	2	3	4	5

-Why?

21) What kind of training your team participated in during the project? Considering that three types of training are often provided in collaborative projects:

-Theoretical training refers to Academic courses, Project focused courses, etc.
-Practical training refers to that performed on non-real system such as tasks, projects, experiments, etc.
-On the Job training refers to practical work performed on the actual system.

-How appropriate did you find the training provided with regard to the needs of your team?

Circle the appropriate number for each type of training

Training type	I find the training				
	Inappropriate				Appropriate
Theoretical training refers to Academic courses, Project focused courses, etc.	1	2	3	4	5
Practical training refers to that performed on non-real system such as tasks, projects, experiments, etc.	1	2	3	4	5
On the Job training refers to practical work performed on the actual system	1	2	3	4	5

-Why? How was the training controlled and monitored (Academic evaluation, tests, dissertation, presentation, practical tasks, etc.)?

22) How deep do you find the knowledge your team acquired during the project?

Circle the appropriate number

I found the knowledge				
Not deep				Deep
1	2	3	4	5

- Why? (Give explanation on whether the required disciplines were covered, was the time spent sufficient? was the number of Algerians trained sufficient? What would be the right number of trainees by component/function and the right background to effectively acquire knowledge?

23) What were the project phases in which your team took part? How deep was your team involved in these phases and how deep were you involved in managing these phases?

Fill in the appropriate cells and Circle the appropriate number for each phase

Project phases		Number of participants and duration (days/hours)	Was the time your team spent in this phase sufficient to effectively acquire knowledge?	How deep your team were involved in the phase	How deep you were involved in the management of the phase
			Insufficient Sufficient	Not deep Deep	Not deep Deep
Phase 0	Mission analysis/needs identification, where mission aims and functions to be performed are defined		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Phase A	Feasibility, where mission general concepts and system functional requirements are defined		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Phase B	Preliminary Definition, where sub-systems functional requirements are defined, all activities and resources for the project development are identified, and preliminary risk assessment is carried out		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Phase C	Detailed Definition, where the detailed technical and functional specifications of the space and ground segments are defined		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Phase D	Manufacturing, Assembly and Testing, where the development and qualification of the system (space and ground segment) and its products (images) are carried out		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	-Procurement (of service or equipment, from third-party)		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	-Manufacturing/development (either within the firm or outside the firm)		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	-Assembly (either within the firm or outside the firm)		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	-Testing (either within the firm or outside the firm)		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Phase E	Launch and operations of the system, where activities related to launch, commissioning, maintaining space segment orbital elements and utilising ground segment are performed		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Phase F	Disposal, referring the activities needed to put the system at customer's (or operator's) disposal		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
other					

Give further details if required.

24) During your participation in the project, what were the project meetings/reviews in which you (or your team) took part?

Circle the appropriate number for each meeting/review

Meetings/reviews	To what extent you (or your team) have contributed in these meetings/reviews? We have	To what extent you (or your team) have learned from these meetings/reviews? We have
	Not contributed ... Contributed heavily	Not learned significantly ... learned Significantly
Mission Definition Review-MDR	1 2 3 4 5	1 2 3 4 5
Preliminary Requirements Review-PRR	1 2 3 4 5	1 2 3 4 5
System Requirements Review-SRR	1 2 3 4 5	1 2 3 4 5
Preliminary Design Review-PDR	1 2 3 4 5	1 2 3 4 5
Critical Design Review-CDR	1 2 3 4 5	1 2 3 4 5
Qualification Review-QR	1 2 3 4 5	1 2 3 4 5
Acceptance Review-AR	1 2 3 4 5	1 2 3 4 5
Operational Readiness Review-ORR	1 2 3 4 5	1 2 3 4 5
Flight Readiness Review-FRR	1 2 3 4 5	1 2 3 4 5
Launch Readiness Review-LRR	1 2 3 4 5	1 2 3 4 5
Commissioning Result Review-CRR	1 2 3 4 5	1 2 3 4 5
End-of-life Review-ELR	1 2 3 4 5	1 2 3 4 5
Mission Close-out Review-MCR	1 2 3 4 5	1 2 3 4 5
Other		

Give further details if required, and indicate whether other representatives from your organisation took part to these reviews/meetings

25) How often did you meet (formally or informally) senior leaders from your organisation during the project in order to discuss about the project? Who were they, in which occasion and what was the aim of the meeting?

26) How reliable was the satellite system?

Tick the appropriate box

The satellite reliability was					
Less than 70%	Between 70 and 80%	Between 80 and 90%	Between 90 and 95%	Between 95 and 99%	More than 99%
☐	☐	☐	☐	☐	☐

27) How complex did you find the satellite project?

Circle the appropriate number for each complexity elements

Elements of complexity	I find the elements
	Low ... High
Number of components developed/customised to fit in the project	1 2 3 4 5
Number of skills (diversity) required for the project	1 2 3 4 5
New knowledge required for the project	1 2 3 4 5

28) How do you find the performances of the satellite system?

Circle the appropriate number

I find the satellite system performances						
Low						High
	1	2	3	4	5	

-Why?

29) How do you find the share of COTS (Commercial off-the-shelf) components in the satellite system?

Circle the appropriate number

I find COTS components share						
Low						High
	1	2	3	4	5	

-Why?

30) How do you find the share of mature components in the satellite system? (e.g. Technology that has an established heritage in space usage, technology that scores high on the scale of Technology Readiness Level-TRL or Manufacturing readiness level-MRL)

Circle the appropriate number

I find mature components share						
Low						High
	1	2	3	4	5	

-Why?

31) With regard to the satellite system, how do you find the knowledge provided by the foreign company during the project for each of the following characteristics:

a/ In terms of number of components about which knowledge has been provided?

Circle the appropriate number

I find the number of components about which knowledge has been provided						
Ordinary						High
	1	2	3	4	5	

-Why?

b/ In terms of Newness (compared to the knowledge already available in this sector)?

Circle the appropriate number

I find the provided knowledge						
Old						New
	1	2	3	4	5	

-Why?

c/ In terms of Breadth (diversity of disciplines involved in the project)?

Circle the appropriate number

The provided knowledge involved						
Few disciplines						Multitude of disciplines
	1	2	3	4	5	

-Why?

d/ In terms of Depth (Depth in the disciplines involved in the project)?

Circle the appropriate number

The provided knowledge was	
Not very deep	Very deep
1 2 3 4 5	

-Why?

32) What are the main engineering tools, equipment, software and facilities used for the development of the satellite? Indicate whether they are COTS.

Phases	The main engineering tools, equipment, software and facilities		
	Used by the foreign company	Your team used during the project	That are available in your facilities in Algeria (or can be easily found elsewhere in Algeria)
During the specification and design			
During the procurement			
During the development			
During the Assembly			
During the integration			
During the test			
During the launch and operations			
Other			

-If these main engineering tools, equipment, software and facilities required for the development of the satellite are not available (or missing) in your facilities in Algeria, tell how important are they? and can they be acquired?

33) List the main documentation and knowledge resources used for the development of the satellite?

Phases	The main documentation and knowledge resources		
	Used by the foreign company	Your team used during the project	That are available in your facilities in Algeria (or can be easily found elsewhere in Algeria)
During the specification and design			
During the procurement			
During the development			
During the Assembly			
During the integration			
During the test			
During the launch and operations			
Other			

-If the main documentation and knowledge resources required for the development of the satellite are not available (or missing) in your facilities in Algeria, tell how important are they? Why couldn't they be acquired? Have you attempted to reproduce them (or some of them)?

-With regard to the project documentation and knowledge resources brought in Algeria, how are they managed? Where are they? How easy are accessible? Who has access to them? Has this documentation been used since then?

-With regard to managerial documentation, have you brought the relevant documentation for satellite project management (including documentation on management tools used during the project)? How is this documentation managed? Where is it? How easy is accessible? Who has access to it? Has this documentation been used since then?

34) On the basis of the knowledge acquired during the project (either through written or unwritten resources), have you (or your team) attempted to prepare any documentation (e.g. theoretical documentation, practical documentation, report/routines/tests/procedures, etc.) for the internal use within your organisation in Algeria? and how important is this documentation for performing independently tasks in Algeria?

35) Have you kept records (e.g. comments, notes) on project progress during the project in addition to the meeting minutes? Are these records archived, stored in a database, diffused internally, re-used?

36) On the basis of the knowledge acquired during the project (either through written or unwritten resources), have you (or your team) attempted to conduct any R&D work, published or not published, (e.g. journal papers, conferences papers, study reports, patent, etc.)? How many works have been done? Who are the persons involved and to which organisation they belong?

37) List the human skills/resources required for satellite development?

Phases	The human skills/resources	
	Used by the foreign company	That are available in your facilities in Algeria (or can be easily found elsewhere in Algeria)
During the specification and design		
During the procurement		
During the development		
During the Assembly		
During the integration		
During the test		
During the launch and operations		
Other		

-If the human skills/resources required for satellite development are not available (or missing) in your facilities in Algeria, tell how important are they? How difficult can they be developed or acquired?

38) Did you have an individual in your team who played the role of team lead engineer? Describe his role and your relationship with him?

-Describe the role of the individual in your team who was in charge of the system engineering function. What was your relationship with him?

39) What was the work language during the project? How comfortable were your team members with this (these) language(s)?

Circle the appropriate number for each language used in the project

Language(s)	The team members were
	Less comfortable — Very comfortable
	1 2 3 4 5
	1 2 3 4 5
	1 2 3 4 5

40) How would you describe your work relationship with your counterpart (or counterparts if there are more than one) and representatives from the foreign firm you regularly deal with?

Circle the appropriate number for each counterpart and representative from the firm

Counterpart(s) and representatives	Intensity of relationship	Formality of relationships	Difficulty of relationships
	Non-intense (mild) — Very intense	Informal (not well defined, flexible) — Formal (well defined)	Easy and not conflicting — Difficult and conflicting
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

-Give further details if required: (For example, they couldn't cooperate further because of restrictions from their company, protection of the technology, the two personalities were different which made communication not easy, contractual terms were not clear enough, incentives in the contract were inappropriate or not sufficient, etc.)

41) How would you describe your counterpart managerial skills, communication skills, and technical knowledge?

Circle the appropriate number for each counterpart

Counterpart	Managerial skills of the counterpart	Communication skills of the counterpart	Technical knowledge of the counterpart
	Limited — High	Limited — High	Limited — High
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

-Give further details if required.

42) What was the institutional management team (or entity) managing from Algeria this project?

-When, how often and to whom did you use to report (and give feedback) on the work progress during the project? (Was this done regularly, occasionally when situation were deemed un-acceptable, formally, informally, etc.?)

-How empowered were you in dealing with technical and managerial issues/questions faced during the project)?

43) Based on your experience, which of the following statement matches your view most closely on the way you were controlling tasks and objectives achievement during the project?

Tick the appropriate box

	Disagree	Tend to disagree	Tend to agree	Agree
I was deeply involved in the project and the choices, I used to guide the foreign firm on how to achieve objectives and provide inputs needed to achieve these objectives	☐	☐	☐	☐
I used to leave the foreign firm on its own, I transferred the risk to it and I was not hold responsible for providing direction	☐	☐	☐	☐
I used to rely on feedback given by my team members and opinions of persons involved in the project on what is acceptable and non-acceptable during the project	☐	☐	☐	☐

44) How would you describe the work relationship between your team members during the project?

Circle the appropriate number

Intensity of relationship	Formality of relationships	Difficulty of relationships
Non-intense (mild) — Very intense	Informal (not well defined, flexible) — Formal (well defined)	Easy and not conflicting — Difficult and conflicting
1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

-Give further details if required:

45) How appropriate did you find your team members prior knowledge (background/ skills/ experience/ knowledge/ profiles) to the project requirements?

Circle the appropriate number

My team members prior knowledge was		
Less than requirement	close to requirement	beyond requirement
1 2	3	4 5

-Why? and what was the most needed knowledge?

46) How skilled did you find your team members during the project? (technical competencies, communication skills, autonomy)

Circle the appropriate number for each criterion

Criterion	The team members skills were Low — High
Technical competencies	1 2 3 4 5
Communication skills	1 2 3 4 5
Autonomy in dealing with problems	1 2 3 4 5

47) Among the members of your team, did you have individuals that stood out from the rest, (e.g. they acquired and hold important share of tacit knowledge, practical skills, theoretical skills, communication skills, etc.). Have these skills formally reported, recognised and/or administratively recorded (in their administrative records, team report, etc.)

48) Describe how was your team involved in tasks related to the assembly, integration and test of the satellite system?

-How deep was this involvement at component level?

-How deep was this involvement at system level?

49) Rank from " 1" to "5" the following sources of knowledge in order of contribution on the whole knowledge your team acquired during the project?
e.g. "1" being the source that contributes the most in the knowledge the team acquired during the project.

Sources of knowledge	Rank	Give details if necessary
Mentor(s) (judgement and appreciation)		
Other individuals and experts (judgement and appreciation)		
Project documentation and databases (blueprints, handbooks, workbooks, guides, system requirements, specifications, interfaces, implementation plans and procedures, test routines, reports, etc.)		
Libraries (books, specialised publications and journals, etc.)		
Other		

50) Based on your experience, which of the following statement matches your view most closely on the focus of the knowledge your team acquired during the project?

Tick the appropriate box

	Disagree	Tend to disagree	Tend to agree	Agree
The provided knowledge was focused on satellite components as independent components, referring to the knowledge that relates to the core design concepts of each component	☐	☐	☐	☐
The provided knowledge was focused on satellite components as part of the whole system or satellite (e.g. interactions between components, process of integration within the larger system, etc.), referring to Architectural knowledge (system integration) required to put together these components in order to form a system?	☐	☐	☐	☐

51) Based on your experience, which of the following statement matches your view most closely on the risk the foreign company was taking when it provided training on the satellite?

Tick the appropriate box

	Disagree	Tend to disagree	Tend to agree	Agree
I feel the training provided was about a technology that has been exploited up to its limits and can be transferred without any risk (e.g. risk of fuelling future competition, security considerations).	☐	☐	☐	☐
I feel the technology was advanced but the training provided was not deep enough to be risky for the foreign company (e.g. risk of fuelling future competition, security considerations).	☐	☐	☐	☐
I feel the technology was advanced, but the foreign company considers the Algerian's capabilities are deemed to be not well enough advanced to make use of the advanced technology.	☐	☐	☐	☐

C. Activities after the project

52) How many individuals from your project team left your organisation after the project? Indicate whether they left the country.

53) Have you maintained relationships with the foreign firm personnel after the project? If yes, are these relationships informal or formal, a courtesy relationships or professional?

54) Have you organised or got involved in any post-project workshop or meeting aiming to record the project experience and the lesson learned? Describe the event, objectives, participants, outcomes, etc.

55) During your activities after the project, have you been involved in any satellite technology development?

- Describe your activities as part of other collaborative satellite projects with foreign companies (Alsat-2A, Alsat-2B, Alsat-1B, etc.)

- Describe your activities outside collaborative satellite projects (local activities, etc.)

56) As part of your satellite technology activities in Algeria, outside the collaborative projects, what were the aim and objectives of your activities?

57) How were the objectives defined? Who defined them?

a/ If the objectives were defined by you, were they discussed and agreed by other upper management levels? Which levels? Did they fit with other objectives?

-How clear do you find these objectives?

Circle the appropriate number

I find objectives clarity						
Low					High	
	1	2	3	4	5	

-How complex do you find these objectives? Considering that complexity is a mix of: Number of developed/customised components required for achieving the objective, Number of skills (diversity) required for the project, and New knowledge required for the project.

Circle the appropriate number

I find objectives complexity						
Low					High	
	1	2	3	4	5	

-How risky do you find these objectives?

Circle the appropriate number

I find objectives risk						
Low					High	
	1	2	3	4	5	

-How flexible are these objectives in terms of specification (freedom to adjust specifications or to completely review objectives)?

Circle the appropriate number

I find objectives specification flexibility						
Low flexibility					High flexibility	
	1	2	3	4	5	

-How flexible are these objectives in terms of funding (freedom to ask more money)?

Circle the appropriate number

I find objectives funding flexibility						
Low flexibility					High flexibility	
	1	2	3	4	5	

-How flexible are these objectives in terms of time (freedom to go beyond timeline)?

Circle the appropriate number

I find objectives timeline flexibility						
Low flexibility						High flexibility
	1	2	3	4	5	

-In general, how ambitious do you find these objectives?

Circle the appropriate number

I find these objectives						
Not ambitious						Ambitious
	1	2	3	4	5	

-How do you report work progress related to these objectives? How often? to whom?

b/ If objectives were defined elsewhere, where exactly? Which management levels? Did they fit with other objectives?

-How clear do you find these objectives?

Circle the appropriate number

I find objectives clarity						
Low						High
	1	2	3	4	5	

-How complex do you find these objectives? Considering that complexity is a mix of: Number of developed/customised components required for achieving the objective, Number of skills (diversity) required for the project, and New knowledge required for the project.

Circle the appropriate number

I find objectives complexity						
Low						High
	1	2	3	4	5	

-How risky do you find these objectives?

Circle the appropriate number

I find objectives risk						
Low						High
	1	2	3	4	5	

-How flexible are these objectives in terms of specification (freedom to adjust specifications or to completely review objectives)?

Circle the appropriate number

I find objectives specification flexibility						
Low flexibility						High flexibility
	1	2	3	4	5	

-How flexible are these objectives in terms of funding (freedom to ask more money)?

Circle the appropriate number

I find objectives funding flexibility					
Low flexibility					High flexibility
1	2	3	4	5	

-How flexible are these objectives in terms of time (freedom to go beyond timeline)?

Circle the appropriate number

I find objectives timeline flexibility					
Low flexibility					High flexibility
1	2	3	4	5	

-In general, how ambitious do you find these objectives?

Circle the appropriate number

I find these objectives					
Not ambitious					Ambitious
1	2	3	4	5	

-How do you report work progress related to these objectives? How often? to whom?

58) How often have you met (formally or informally) senior leaders from your organisation to discuss about these objectives during the period from the end of the project until now? Who were they? In which occasion? and what was the aim of the meeting?

59) How motivated were you in order to achieve these objectives?

Circle the appropriate number

My motivation was					
Low					High
1	2	3	4	5	

-Why, what motivated you most, what motivated you less?

60) Based on your experience on satellite, how is the related technology evolving (rate of system development) and how different are the new systems (architecture, components) compared to the old ones and how different are the processes of their development? (Even/uneven, slow rate, fast, too fast, completely different, similar, etc.). Indicate changes for the case of Algerian satellites.

61) With regard to your activities in Algeria that are related to satellite technology, are you leading or part of a larger team/project, or your activity is rather individual?

a/ If you are leading or part of a larger team/project

-What is the size of this team/project (number of personnel, specialisation, position within the organisation, location, organisation, etc.)? Indicate if members were part of any collaborative projects with foreign firms and indicate which projects?

-If this team involved more than one organisation, was this collaboration framed by explicit agreement between organisations or just informal collaboration? What is the core-competencies that you distinguish you or your organisation from the others?

-How would you describe work relationship with the team/project members?

Circle the appropriate number for each member

Intensity of relationship	Formality of relationships	Difficulty of relationships
Non-intense (mild) — Very intense	Informal (not well defined, flexible) — Formal (well defined)	Easy and not conflicting — Difficult and conflicting
1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

Give further details if required:

-Describe the team/project structure. How appropriate do you find this structure for satellite projects?

-Describe the management documentation and tools used (system of monitoring of schedules and budget, supply management, quality management, cost management, stock management, etc.). How often do team/project members use these tools? Among these management tools, what were already used during the collaborative project (the same or similar tools)?

b/ If your activity is rather individual, have you built your own network of individuals/specialists/ academics (within or outside your organisation) that can contribute in your work? (Number of personnel, specialisation, positions, organisations, etc.). Give examples

62) With regard to your activities in Algeria that are related to satellite technology, how is the related supply management function performing?

63) With regard to your activities in Algeria that are related to satellite technology and knowledge you acquired during the project,

- Have you benefited from a training that is related (or complements) to the knowledge you acquired during the project? (Indicate training that was provided outside other satellite collaborative projects)

- How easily do you participate in seminars and conferences that are related to your area of interest?

- How easily do you access to patent information related to the technology you managed during the project?

64) With regard to your activities in Algeria that are related to satellite technology and knowledge you acquired during the project, have you trained, mentored, supervised people in your organisation? Give details on trainees, how many trainees? Why were they trained? How long the training lasted? What kind of training you provided?

-As part of the same activity, how easily you can recruit qualified personnel from the labour market? Indicate how effective is the recruitment process within your organisation (time, anticipation, targeting skilled persons, etc.)?

65) Do you have in your organisation in Algeria any entity (department, laboratory, centre, etc.) that is in charge of managing satellite development projects? What is your relation to this entity?

66) Indicate your activities in Algeria that are related to, or make use of, the knowledge you acquired during the project?

Fill in the table considering that:

- “Research” refers to basic research
- “Development” refers to translating technical and scientific knowledge into products, processes, and services

- “Engineering” refers to very practical aspects

Activity categories	Examples and description (precise whether it is individual activity or team activity)
Research	
Development	
Engineering	
Teaching	
Other	

67) In your view, what would be the share of your activities related to satellite project management, compared to all your activities in Algeria?

Circle the appropriate number

Activities related to satellite management project represent				
Small share of my total activity in Algeria				Big share of my total activity in Algeria
1	2	3	4	5

68) In general, how do you find the nature of your activities in Algeria? Fill in the table considering that:
- “Research” refers to basic research
- “Development” refers to translating technical and scientific knowledge into products, processes, and services
- “Engineering” refers to very practical aspects

Activities	Proportions		Give examples, explanations and details
Administrative activities	…….%		
Satellite technology management activities	…….%		
Scientific activities	…….%	………% Research	
		………% Development	
		………% Engineering	
		……..% Teaching	
Other	……..%		

D. Final suggestions

69) Based on your experience during the project, how reasonable would be the objective of developing similar or equivalent satellites locally?

Circle the appropriate number

I find the objective of developing similar or equivalent satellites locally				
Not reasonable objective				Very reasonable objective
1	2	3	4	5

-Why? What would be the core competencies and functions to develop within your organisation, those to develop locally in Algeria but outside your organisation, and those to import from foreign firms?

70) Based on your experience on satellite technology, which of the following statement matches your view most closely in order to start developing satellite locally?

Tick the appropriate box

	Disagree	Tend to disagree	Tend to agree	Agree
I would suggest to work with foreign firms on relatively old, less complex technology providing relatively modest or low system performances	☐	☐	☐	☐
I would suggest to work with foreign firms on relatively new, complex technology providing relatively high system performances	☐	☐	☐	☐
I would prefer to work **more often** on technology with higher risk of failure (non-completion of the project or system failure) rather than working **less often** on technology with lesser risk of failure	☐	☐	☐	☐

71) How averse to risk do you find your organisation when it comes to developing satellite locally?

Circle the appropriate number

I find my organisation				
Low risk averse				High risk averse
1	2	3	4	5

-Why

72) How motivated are you right now in order to participate in developing satellite locally?

Circle the appropriate number

My motivation is				
Low				High
1	2	3	4	5

-Why?

73) How confident do you feel about your current abilities in order to manage satellite project development locally?

Circle the appropriate number

My confidence in my current abilities is				
Low				High
1	2	3	4	5

-Why?

74) How satisfied are you with your career development in your organisation?

Circle the appropriate number

With regard to my career development, my satisfaction is				
Low				High
1	2	3	4	5

-Why?

75) In general, how conducive do you find the environment within your organisation for your work and the development of your activities?

Circle the appropriate number

I find the environment in my organisation				
Not conducive				Very conducive
1	2	3	4	5

-Why?

76) In general, how conducive do you find the national environment for your work and the development of your activities?

Circle the appropriate number

I find the national environment				
Not conducive				Very conducive
1	2	3	4	5

-Why?

77) How confident do you feel about the process of building satellite system in Algeria?

Circle the appropriate number

With regard to building satellite system in Algeria, I feel				
Not confident				Very confident
1	2	3	4	5

-Why?

Appendix 1-e: Questionnaires for project managers (French version)

Date:	Participant ID:

Questions sur la mise en place de capacités de développement de petits satellites en Algérie

adressées au chef de projet Alsat-1

Objectifs de le recherche: Recueillir des données qui permettent de mieux comprendre le processus de transfert des technologies satellitaires pour le cas de l'Algérie. Cela permettra aux Algériens d'avoir une appréciation sur l'efficacité des mécanismes qu'ils utilisent pour mettre en place un potentiel de développement des technologies de petits satellites, et fournira des indications sur les processus les plus efficaces à adopter pour transférer les technologies satellitaires.

Orientations pour répondre aux questions:

- Utilisez, à votre convenance, l'arabe, le français ou l'anglais au moment de répondre.
- Certaines réponses sont formulées en encerclant un nombre ① ou en cochant une case √ , d'autres réponses exigent des commentaires écrits. Si l'espace prévu sur le formulaire est insuffisant pour vos commentaires, utilisez des feuilles supplémentaires. Vous pouvez également joindre des documents que vous estimeriez pertinents.
- Une fois que vous aurez répondu aux questions, le chercheur lui-même vous interviewera (face-à-face) lors d'une réunion, à convenir, pour s'assurer de la bonne compréhension des questions et de la bonne formulation des réponses.
- Toutes les réponses seront traitées de manière confidentielle. Seul le chercheur aura accès à ces réponses. Votre identité ne sera pas révélée. Vous serez identifié seulement par un code (ex. participant A, B, C, etc.).

Sections couvertes:

A. Informations générales
B. Activités dans le cadre du projet
C. Activités après le projet
D. Suggestions finales

A. Informations générales

1) Quelle est votre formation? Indiquez les institutions de formation et les périodes correspondantes (Indiquez à partir du «Baccalauréat»).

Formation/Diplôme	Période	Institution de formation

2) Quel est votre parcours professionnel? Indiquez les organisations (employeurs) et les périodes correspondantes.

Postes, Responsabilités professionnelles	Période	Organisations (employeurs)

3) Avant de participer à ce projet, aviez-vous déjà pris part à d'autres projets ou activités impliquant des étrangers (Exemple : projets conjoints, négociations, R&D conjoints, etc.)?

4) Avant de participer à ce projet, avez-vous déjà utilisé (ou avez-vous été formé sur) des outils de management de projet?

5) Avant de participer à ce projet, avez-vous été formé sur les technologies satellitaires?

6) Quand aviez-vous rejoint l'équipe du projet? Pourquoi et comment aviez-vous été sélectionné pour le projet? Décrivez l'ensemble du processus.

7) Combien de temps avant le début du projet aviez-vous été informé de votre sélection et de votre désignation comme chef de projet?

8) Aviez-vous participé à la sélection des membres de votre équipe ? Si oui, jusqu'à quel degré?

9) Aviez-vous participé à des activités préparatoires liées au projet avant son début? (Par exemple: l'évaluation des technologies, négociation du projet avec la firme étrangère, des études de conception ou de spécification, des sessions d'initiation au projet, formation pratique, formation théorique, formation de langue, etc.). Expliquez quelles étaient ces activités? Comment elles étaient utiles pour le projet? Est-ce que leurs durées étaient appropriées ? Comment auraient-elles pu être effectuées pour un meilleur résultat?

10) Combien de fois aviez-vous rencontré (d'une manière formelle ou informelle) des hauts dirigeants de votre organisation avant le début du projet afin de discuter sur le projet? Qui étaient-ils? A quelle occasion et quel était le but des rencontres?

11) Quelle était votre motivation avant le début de ce projet?

Encerclez le nombre approprié

Le niveau de ma motivation était				
Bas				Haut
1	2	3	4	5

-Pourquoi? Qu'est-ce qui vous motivait le plus, qu'est-ce qui vous motivait le moins?

12) Quelle était le niveau de motivation des membres de votre équipe avant le début de ce projet?

Encerclez le nombre approprié

Le niveau de leur motivation était
Bas Haut
1 2 3 4 5

-Pourquoi? Qu'est-ce qui les motivait le plus, qu'est-ce qui les motivait le moins?

B. Activités dans le cadre du projet

13) Quelle est la taille de votre équipe? Décrivez votre schéma de gestion (management chart) et indiquez les domaines de spécialisation par individu?

14) Quel(s) composant (s) (ex. Unité/Module/Sous-système/Système) ou fonction (s) vous avez managé dans le cadre de vos missions ? Cochez la ou les cases appropriées. Donnez une indication sur la profondeur de votre implication dans le management de ces composants et ces fonctions ? Nombre d'individus de votre équipe impliqués ? Nombre d'Algériens impliqués, autres que ceux de votre équipe?

composant (s) (ex: Unité/Module/Sous-système/Système) ou fonction (s)	Mon implication dans le management était Non profonde Profonde	Nombre d'individus de mon équipe impliqués	Nombre d'Algériens impliqués, autres que ceux de mon équipe
Segment spatial (Space Segment)	1 2 3 4 5		
Plate-forme (Platform)	1 2 3 4 5		
Structure	1 2 3 4 5		
Contrôle thermique (Thermal control)	1 2 3 4 5		
Alimentation de bord (On-board power supply)	1 2 3 4 5		
contrôle d'attitude (Attitude control)	1 2 3 4 5		
Traitement des données (Data handling)	1 2 3 4 5		
Charge utile (Payload)	1 2 3 4 5		
Intégration, Assemblage et test (Integration-Assembly-Test)	1 2 3 4 5		
Intégration plate-forme (Spacecraft Integration)	1 2 3 4 5		
Intégration plate-forme avec charge utile (Payload-to-spacecraft Integration)	1 2 3 4 5		
Test Satellite (Satellite Testing)	1 2 3 4 5		
Equipement de servitude au Sol (Ground Support Equipment-GSE)	1 2 3 4 5		
Segment Sol (Ground Segment)	1 2 3 4 5		
Contrôle de mission (Mission Control)	1 2 3 4 5		
Contrôle charge utile (Payload Control)	1 2 3 4 5		
Système de communication (Communication System)	1 2 3 4 5		
Fonctions de support (Support Functions)	1 2 3 4 5		
Management (gestion du programme) - Management task (Programme Management)	1 2 3 4 5		
ingénierie système - Engineering tasks (System Engineering)	1 2 3 4 5		
Assurance de produit (Product assurance tasks)	1 2 3 4 5		
Formation (Training)	1 2 3 4 5		
Lancement, Exploitation et entretien (Launch, Operations and Maintenance)	1 2 3 4 5		
Lancement (Launch)	1 2 3 4 5		
Exploitation et entretien (Operations and Maintenance)	1 2 3 4 5		
Autres			

15) Où et comment le système satellitaire a été développé? (Conçu, manufacturé, intégré, testé, complètement par la firme dans ses installations, partiellement, etc.).

-Si le système satellitaire a été développé partiellement à l'extérieur de la firme, quels étaient les composants développés à l'extérieur? Quelle est la profondeur des connaissances de la firme (Prime) sur ces composants et pourquoi elle a eu recours à ces fournisseurs/sous-traitants? Décrivez comment la collaboration technique entre la firme (Prime) et ses fournisseurs/sous-traitants a été effectuée?

- Si le développement du satellite a été partiellement externalisé, quel est votre degré d'implication dans le management du développement à l'extérieur (ex. participation dans le management du développement, formation sur le management du développement externalisé, chez des fournisseurs/sous-traitants, Réunions/échanges)?

16) Le chef de projet de satellite (représentant le client) peut avoir plusieurs rôles dans le projet, alors:

-Quel était votre rôle (obligations/missions/objectifs) en tant que représentant du client (ex. assurer la bonne exécution du contrat, négociations avec les représentants de la firme étrangère, etc.)?

-Quel était votre rôle (obligations/missions/objectifs) en tant que chef d'équipe (ex. motiver l'équipe, donner des conseils, encourager et faciliter le développement de la communication, et coordonner)?

-Quel était votre rôle (obligations/missions/objectifs) en tant que stagiaire ou apprenti des outils de management (ex. participer à des sessions de formation sur les outils de management, etc.)? Avez-vous été formé sur les outils et techniques de management (structure de projet, système de suivi des calendriers et du budget, gestion des approvisionnements, gestion de la qualité, etc.)? Avez-vous utilisé ces outils? Est-ce que les membres de votre équipe ont utilisé ces outils?

-Quel était votre rôle (obligations/missions/objectifs) comme ingénieur ou leader technique? (ex. si vous participez à des activités techniques)

-Quelles seraient les proportions des tâches liées aux différents rôles lors de votre participation au projet?

Rôle (ou nature des tâches)	Proportions (%)
Représentant du client	……….%
Chef d'équipe Algérien	……….%
Stagiaire ou apprenti des outils de management	……….%
Ingénieur ou leader technique	……….%
Autres :	

17) Selon vous, quelles sont les fonctions qui sont essentielles pour le management d'un projet satellite?

18) En ce qui concerne les tâches nécessitant des compétences dans le management des satellites, avez-vous trouvé vos connaissances préalables (formation/compétences/connaissances/expériences) appropriées aux exigences

Encerclez le nombre approprié

Mes connaissances préalables étaient				
Inferieures aux exigences		Proches des exigences		Au-delà des exigences
1	2	3	4	5

-Pourquoi? et quelles sont les connaissances qui ont été les plus requises?

19) Comment avez-vous trouvé la clarté des objectifs de votre participation au projet?

Encerclez le nombre approprié

J'ai trouvé les objectifs				
Pas clairs				clairs
1	2	3	4	5

-Pourquoi?

-Selon vous, laquelle des déclarations suivantes correspond le plus à votre point de vue sur les priorités dans ce projet?

Cochez la case appropriée

	Je suis en désaccord	Plutôt en désaccord	Plutôt en accord	Je suis en accord
La priorité de ce projet a été l'acquisition d'un système de satellite et son déploiement	☐	☐	☐	☐
La priorité de ce projet a été d'apprendre à développer un système de satellite	☐	☐	☐	☐

20) Comment avez-vous trouvé l'ambition des objectifs de votre participation au projet?

Encerclez le nombre approprié

J'ai trouvé les objectifs						
Pas ambitieux						Ambitieux
	1	2	3	4	5	

-Pourquoi?

21) Quel type de formation votre équipe a suivi durant le projet? Considérant que trois types de formation sont souvent dispensés dans des projets de satellites :

-Formation Théorique: Cours académiques, cours axés sur des projets, etc.

-Formation Pratique: Effectuées sur des systèmes non-réels, tels que des projets et tâches spécifiques, expériences, etc.

-Formation sur les systèmes Réels (On Job training): Travaux pratiques effectués sur des systèmes réels.

-Est-ce que la formation a été appropriée aux besoins de votre équipe?

encerclez le nombre approprié pour chaque type

Type de formation	J'ai trouvé la formation					
	Inappropriée					appropriée
Formation Théorique : Cours académiques, cours axés sur des projets, etc.	1	2	3	4	5	
Formation Pratique : Effectuées sur des systèmes non-réels, tels que des projets et tâches spécifiques, expériences, etc.	1	2	3	4	5	
Formation sur les systèmes Réels (On Job training) : Travaux pratiques effectués sur des systèmes réels	1	2	3	4	5	

-Pourquoi? Comment les formations ont été contrôlées et supervisées (évaluation académique, tests, dissertation, présentation, travaux pratiques, etc.)?

22) Comment avez-vous trouvé la profondeur des connaissances acquises par votre équipe durant le projet?

Encerclez le nombre approprié

J'ai trouvé les connaissances						
Pas profondes						Profondes
	1	2	3	4	5	

-Pourquoi? (Donnez des explications sur les disciplines requises et celles qui ont été couvertes, est ce que le temps passé durant les formations était suffisant? Est-ce que le nombre d'Algériens formés était suffisant? Quel serait le nombre approprié de stagiaires et les profils (background) appropriés pour une acquisition efficace des connaissances?

23) Quelles sont les phases du projet dans lesquelles vous avez pris part ? Quel était le niveau d'implication de votre équipe dans ces phases ? et quel était votre niveau d'implication dans le management de ces phases?

Remplissez les cellules et encerclez le nombre approprié pour chaque phase

Phases de projet		Nombre de participants et durées (jours /heures)	Est-ce que le temps passé par l'équipe dans cette phase était suffisant pour acquérir efficacement les connaissances?	Le niveau d'implication de mon équipe dans ces phases était	Mon niveau d'implication dans le management de ces phases était
			Insuffisant Suffisant	Pas profond profond	Pas profond profond
Phase 0	Analyse de mission / identification des besoins, où les objectifs et les fonctions de la mission sont définis (Mission analysis/needs identification, where mission aims and functions to be performed are defined)		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Phase A	Faisabilité, où les concepts généraux de la mission et les exigences fonctionnelles du système sont définies (Feasibility, where mission general concepts and system functional requirements are defined)		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Phase B	Définition préliminaire, où les exigences fonctionnelles des sous-systèmes sont définies, toutes les activités et les ressources pour le développement du projet sont identifiés, l'évaluation préliminaire des risques est effectuée (Preliminary Definition, where sub-systems functional requirements are defined, all activities and resources for the project development are identified, and preliminary risk assessment is carried out)		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Phase C	Définition détaillée, lorsque les spécifications techniques et fonctionnelles détaillées des segments, spatial et sol, sont définis (Detailed Definition, where the detailed technical and functional specifications of the space and ground segments are defined)		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Phase D	Fabrication, assemblage et essais, où le développement et la qualification du système (segment spatial et sol) et ses produits (images) sont réalisées (Manufacturing, Assembly and Testing, where the development and qualification of the system (space and ground segment) and its products (images) are carried out)		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	- Approvisionnement (de service ou d'équipement, auprès des tiers). (Procurement (of service or equipment, from third-party))		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	- Fabrication/Développement (soit au sein de l'entreprise ou à l'extérieur de l'entreprise) (Manufacturing/development (either within the firm or outside the firm))		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	- Assemblage (Soit au sein de l'entreprise ou à l'extérieur de l'entreprise) (Assembly (either within the firm or outside the firm))		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	- Tests ou essais (Soit au sein de l'entreprise ou à l'extérieur de l'entreprise) (Testing (either within the firm or outside the firm))		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Phase E	Lancement et exploitation du système, où les activités liées au lancement, la mise en service, le maintien des éléments orbitaux du segment spatial en utilisant le segment sol sont effectuées (Launch and operations of the system, where activities related to launch, commissioning, maintaining space segment orbital elements and utilising ground segment are performed)		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Phase F	Livraison, il s'agit des activités nécessaires pour mettre le système à la disposition du client (ou de l'opérateur). (Disposal, referring the activities needed to put the system at customer's (or operator's) disposal)		1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
Autres					

Donnez plus de détails si nécessaire.

24) Durant le projet, quelles sont les réunions/revues dans lesquelles vous (ou votre équipe) avez pris part ?

Encerclez le nombre approprié pour chaque réunion/revue

Réunions/Revues	Est-ce que vous (ou votre équipe) avez contribué dans ces réunions/revues	Est-ce que vous (ou votre équipe) avez appris dans ces réunions/revues?
	On n'a pas contribuée — On n'a fortement contribué	Je n'ai pas appris beaucoup — J'ai beaucoup appris
Revue de Définition de Mission (Mission Definition Review-MDR)	1 2 3 4 5	1 2 3 4 5
Revue des Spécifications Préliminaires (Preliminary Requirements Review-PRR)	1 2 3 4 5	1 2 3 4 5
Revue des Spécifications Système (System Requirements Review-SRR)	1 2 3 4 5	1 2 3 4 5
Revue de Conception Préliminaire (Preliminary Design Review-PDR)	1 2 3 4 5	1 2 3 4 5
Revue de Conception Critique (Critical Design Review-CDR)	1 2 3 4 5	1 2 3 4 5
Revue de Qualification (Qualification Review-QR)	1 2 3 4 5	1 2 3 4 5
Revue d'Acceptation (Acceptance Review-AR)	1 2 3 4 5	1 2 3 4 5
Revue d'Aptitude Opérationnelle (Operational Readiness Review-ORR)	1 2 3 4 5	1 2 3 4 5
Revue d'Aptitude au Vol (Flight Readiness Review-FRR)	1 2 3 4 5	1 2 3 4 5
Revue d'Aptitude au Lancement (Launch Readiness Review-LRR)	1 2 3 4 5	1 2 3 4 5
Revue des Résultats de Mise en service (Commissioning Result Review-CRR)	1 2 3 4 5	1 2 3 4 5
Revue de Fin de Vie (End-of-life Review-ELR)	1 2 3 4 5	1 2 3 4 5
Revue de Clôture de la Mission (Mission Close-out Review-MCR)	1 2 3 4 5	1 2 3 4 5
Autres		

Donnez plus de détails si nécessaire, et indiquez si d'autres représentants de votre organisation ont pris part à ces revues/réunions

25) Combien de fois aviez-vous rencontré (d'une manière formelle ou informelle) des hauts dirigeants de votre organisation au cours du projet afin de discuter sur le projet? Qui étaient-ils? A quelle occasion et quel était le but de ces rencontres?

26) Quelle est la fiabilité du système satellitaire?

Cochez la case appropriée

La fiabilité du satellite était					
inférieure à 70%	entre 70 et 80%	entre 80 et 90%	entre 90 et 95%	entre 95 et 99%	Supérieure à 99%
☐	☐	☐	☐	☐	☐

27) Quelle est la complexité du système satellitaire?

Encerclez le nombre approprié pour chaque élément de complexité

Eléments de complexité	La complexité de cet élément est
	Basse — Haute
Nombre de composants à développer/personnaliser pour l'élaboration du système	1 2 3 4 5
Nombre de compétences (diversité) nécessaires pour le projet	1 2 3 4 5
Nouvelles connaissances nécessaires pour le projet	1 2 3 4 5

28) Quelle est la performance du système satellitaire?

Encerclez le nombre approprié

La performance du système satellitaire est						
Basse						Haute
	1	2	3	4	5	

-Pourquoi?

29) Quelle est la part des COTS (Commercial off-the-shelf) dans le système satellitaire?

Encerclez le nombre approprié

La part des COTS était						
Basse						Haute
	1	2	3	4	5	

-Pourquoi?

30) Quelle est la part des éléments matures dans le système satellitaire? (ex. la technologie qui a un héritage établi dans l'utilisation dans l'espace, la technologie qui a des scores élevés sur les échelles Technology Readiness Level-TRL ou Manufacturing readiness level-MRL)

Encerclez le nombre approprié

La part des éléments matures était						
Basse						Haute
	1	2	3	4	5	

-Pourquoi?

31) En ce qui concerne le système satellitaire, Comment trouviez-vous les connaissances fournies par la société étrangère au cours du projet, pour chacune des caractéristiques suivantes:

a/ En terme de nombre de composants sur lesquels des connaissances ont été transmises?

Encerclez le nombre approprié

Je trouve le nombre de composants sur lesquels des connaissances ont été transmises						
Ordinaire						Haut
	1	2	3	4	5	

-Pourquoi?

b/ En terme de Nouveauté (par rapport à la connaissance déjà disponible dans ce secteur)?

Encerclez le nombre approprié

Les connaissances fournies étaient						
Vielles						Nouvelles
	1	2	3	4	5	

-Pourquoi?

c/ En terme de d’ampleur (diversité des disciplines impliquées)?

Encerclez le nombre approprié

Les connaissances fournies impliquent						
Peu de disciplines						Beaucoup de disciplines
	1	2	3	4	5	

- Pourquoi?

d/ En terme de Profondeur (par rapport aux disciplines impliquées)?

Encerclez le nombre approprié

Les connaissances fournies étaient						
Pas très profondes						Très profondes
	1	2	3	4	5	

-Pourquoi?

32) Donnez la liste des outils d'ingénierie, équipements, logiciels et installations utilisés pour le développement du système satellitaire ? Indiquez s'ils sont COTS?

Phases	Les outils d'ingénierie, équipements, logiciels et installations		
	Utilisés par la compagnie étrangère	Que votre équipe a utilisé durant le projet	Qui sont disponibles dans vos installations en Algérie (ou peuvent être facilement trouvés ailleurs en Algérie)
Durant la spécification et la conception (specification and design)			
Durant l'approvisionnement (procurement)			
Durant le développement			
Durant l'Assemblage (Assembly)			
Durant l'intégration (integration)			
Durant les tests/essaie (test)			
Durant le lancement et l'exploitation (launch and operations)			
Autres			

-Si les outils d'ingénierie, équipements, logiciels et installations nécessaires pour le développement du système satellitaire ne sont pas disponibles (ou manquant) dans vos installations en Algérie? A quel point ils sont importants ? et peuvent-ils être achetées ou acquis ?

33) Donnez la liste de la documentation et des ressources documentaires majeures utilisées pour le développement du système satellitaire?

Phases	La documentation et les ressources documentaires		
	Utilisées par la compagnie étrangère	Que votre équipe a utilisé durant le projet	Qui sont disponibles dans vos installations en Algérie (ou peuvent être facilement trouvées ailleurs en Algérie)
Durant la spécification et la conception (specification and design)			
Durant l'approvisionnement (procurement)			
Durant le développement			
Durant l'Assemblage (Assembly)			
Durant l'intégration (integration)			
Durant les tests/essaie (test)			
Durant le lancement et l'exploitation (launch and operations)			
Autres			

-Si la documentation et les ressources documentaires majeures et qui sont nécessaires pour le développement du système satellitaire ne sont pas disponibles (ou manquant) dans vos installations en Algérie? A quel point elles sont importantes ? Pourquoi elles n'ont pas pu être achetées ou acquises? Avez-vous essayé de les reproduire (même en partie)?

-En ce qui concerne la documentation du projet et les ressources documentaires ramenées en Algérie, Comment sont-elles gérées? Où sont-elles? Est-ce qu'elles sont facilement accessibles? Qui a accès à elles? Est-ce que cette documentation a été utilisée depuis lors?

-En ce qui concerne la documentation managériale, avez-vous ramené la documentation pertinente pour la gestion d'un projet satellitaire (y compris la documentation sur les outils de management utilisés durant le projet)? Comment cette documentation est gérée? Où est-elle? Est-ce qu'elle est facilement accessible? Qui a accès à elle? Est-ce que cette documentation a été utilisée depuis lors?

34) En se basant sur les connaissances acquises au cours du projet (soit à travers des ressources écrites ou non écrites), avez-vous (vous-même ou votre équipe) tenté de préparer une documentation (ex. documentation théorique, documentation pratique, rapport/routines/tests/procédures, etc.) pour un usage interne au sein de votre organisation en Algérie? Et quelle est l'importance de cette documentation pour effectuer indépendamment des tâches en Algérie?

35) Avez-vous conservé vos propres documents de suivi, vos commentaires, notes, etc. portant sur l'avancement du projet, en plus des minutes de réunion (et documents officielles)? Est-ce que ces documents sont archivés, stockés dans des bases de données, diffusés en interne, réutilisés?

36) En se basant sur les connaissances acquises au cours du projet (soit à travers des ressources écrites ou non écrites), avez-vous (vous-même ou votre équipe) tenté de mener une activité de R&D, publiée ou non publiée, (ex. articles de revues, conférences, rapports d'études, brevets, etc.)? Combien de travaux ont été menés? Quelles sont les personnes impliquées et quelles sont leurs organisations/institutions d'appartenance?

37) Donnez la liste des ressources humaines et compétences nécessaires pour le développement d'un système satellitaire?

Phases	Les ressources humaines et compétences	
	Utilisées par la compagnie étrangère	Qui sont disponibles dans vos installations en Algérie (ou peuvent être facilement trouvées ailleurs en Algérie)
Durant la spécification et la conception (specification and design)		
Durant l'approvisionnement (procurement)		
Durant le développement		
Durant l'Assemblage (Assembly)		
Durant l'intégration (integration)		
Durant les tests/essaie (test)		
Durant le lancement et l'exploitation (launch and operations)		
Autres		

-Si les ressources humaines et compétences nécessaires pour le développement d'un système satellitaire ne sont pas disponibles (ou manquant) dans vos installations en Algérie? A quel point elles sont importantes ? A quel point il est difficile de les former ou de les recruter ?

38) Aviez-vous une personne dans votre équipe qui a joué le rôle de l'ingénieur en chef (lead engineer)? Décrivez son rôle et votre relation avec lui?

-Décrivez le rôle de l'individu de votre équipe qui était en charge de la fonction d'ingénierie système (system engineering). Quelle était votre relation avec lui ?

39) Quelle était la langue (ou les langues) de travail durant le projet? Est-ce que votre équipe était à l'aise avec cette langue (ou ces langues)?

Encerclez le nombre approprié pour chaque langue utilisée durant le projet

Langue(s)	L'équipe était Moins à l'aise Très à l'aise
	1 2 3 4 5
	1 2 3 4 5
	1 2 3 4 5

40) Comment qualifiez-vous votre relation de travail avec votre/vos homologue(s) ou les représentants de la firme étrangère avec qui vous traitiez régulièrement?

Encerclez le nombre approprié pour chacun des homologues et représentants de la firme

Homologue ou représentant	Intensité des relations	Formalité des relations	Difficulté des relations
	Non-intenses (légères) — très intenses	Informelles (pas bien définies, flexibles) — Formelles (bien définies)	Faciles et pas conflictuelles — Difficiles et conflictuelles
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

-Donnez plus de détails si nécessaire: (ex. il ne pouvait pas coopérer plus en raison des restrictions appliquées par son entreprise, la protection de la technologie, les deux personnalités étaient différentes ce qui rendait la communication difficile, les termes contractuels ne prévoyaient pas cela, les incitations (incentives) dans le contrat étaient inappropriées ou insuffisantes, etc.)

41) Comment qualifiez-vous les connaissances managériales, les capacités communicatives, les connaissances techniques de vos homologues?

Encerclez le nombre approprié pour chacun des homologues

Homologues	Connaissances managériales	Capacités communicatives	Connaissances techniques
	Limitées — Elevées	Limitées — Elevées	Limitées — Elevées
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

- Donnez plus de détails si nécessaire.

42) Quelle était l'équipe managériale ou l'entité institutionnelle qui gérait le projet à partir de l'Algérie ?

-Quand, à quelle fréquence et à qui aviez-vous l'habitude de rapporter (et donner des feedbacks) sur l'avancement des travaux durant le projet? (Est-ce que cela était fait régulièrement, occasionnellement lorsque la situation était jugée inacceptable, de façon formelle, de façon informelle, etc.?)

-Quelle était le degré d'autonomie dont vous aviez pour régler des questions/problèmes techniques et managériaux durant le projet?

43) Sur la base de votre expérience, laquelle des déclarations suivantes correspond le plus à votre point de vue sur la façon avec laquelle vous aviez l'habitude de contrôler l'accomplissement des tâches et objectifs durant le projet?

Cochez la case appropriée

	Je suis en désaccord	Plutôt en désaccord	Plutôt en accord	Je suis en accord
J'étais très impliqué dans les choix liés au projet, j'orientais la firme étrangère sur la façon d'atteindre les objectifs et de fournissais les intrants (inputs) nécessaires pour atteindre ces objectifs	☐	☐	☐	☐
J'intervenais peu, je transférais le risque vers la firme étrangère et je n'étais pas tenu responsable de leur choix	☐	☐	☐	☐
Je comptais sur le feedback donné par les membres de mon équipe et les opinions des personnes impliquées dans le projet sur ce qui est acceptable et non-acceptable durant le projet.	☐	☐	☐	☐

44) Comment qualifiez-vous la relation de travail entre les membres de votre équipe durant le projet ?

Encerclez le nombre approprié

Intensité des relations	Formalité des relations	Difficulté des relations
Non-intenses (légères) — très intenses	Informelles (pas bien définies, flexibles) — Formelles (bien définies)	Faciles et pas conflictuelles — Difficiles et conflictuelles
1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

-Donnez plus de détails si nécessaire

45) Avez-vous trouvé les connaissances préalables (formation/compétences/connaissances/expériences) de votre équipe appropriées aux exigences du projet ?

Encerclez le nombre approprié

Les connaissances préalables de l'équipe étaient		
Inferieures aux exigences	Proches des exigences	Au-delà des exigences
1 2	3	4 5

-Pourquoi? et quelles sont les connaissances qui ont été les plus requises?

46) Comment qualifiez-vous les compétences des membres de votre équipe durant le projet? (Connaissances techniques, capacités communicatives, autonomie)

Encerclez le nombre approprié pour chaque critère

Critères	Les compétences des membres de l'équipe étaient Limitées — Elevées
Connaissances techniques	1 2 3 4 5
Capacités communicatives	1 2 3 4 5
Autonomie en face des problèmes	1 2 3 4 5

47) Parmi les membres de votre équipe, avez-vous des individus qui se distinguent du reste, (ex. ils ont acquis et détiennent une part importante de la connaissance tacite, des compétences pratiques, les compétences théoriques, les compétences de communication, etc.). Est-ce cela a été formellement déclaré, reconnu et/ou administrativement enregistré (dans leurs dossiers administratifs, rapports de l'équipe, etc.)

48) Décrivez comment votre équipe était impliquée dans des tâches liées à l'Assemblage, Intégration et Test, du système satellitaire?

-Quelle était la profondeur de cette implication au niveau des composants?

-Quelle était la profondeur de cette implication au niveau du système?

49) Veuillez classer de "1" à "5" les sources de connaissances suivantes en fonction de leur contribution dans l'ensemble des connaissances que votre équipe avez acquises durant le projet?
Exemple : "1" étant la source qui contribue le plus dans les connaissances acquises durant le projet.

Sources de connaissances	classement	Donnez des détails si nécessaire.
Mentor (s) (son jugement et appréciation)		
D'autres individus et experts (leurs jugements et appréciations)		
la documentation et les bases de données du projet (plans, manuels, guides, exigences système, spécifications, interfaces, plans et procédures d'implémentation, routines de test, rapports, etc.) (Blueprints, handbooks, workbooks, guides, system requirements, specifications, interfaces, implementation plans and procedures, test routines, reports, etc.)		
Bibliothèques (livres, publications et revues spécialisées, etc.)		
Autres		

50) Sur la base de votre expérience, laquelle des déclarations suivantes correspond le plus à votre point de vue sur l'orientation des connaissances que votre équipe avez acquises durant le projet?

Cochez la case appropriée

	Je suis en désaccord	Plutôt en désaccord	Plutôt en accord	Je suis en accord
Les connaissances fournies ont été axées sur les composants du satellite en tant que composants indépendant. Elles portaient sur les concepts de de base pour chaque composant	☐	☐	☐	☐
Les connaissances fournies ont été axées sur les composants du satellite en tant qu'élément appartenant à l'ensemble du système satellitaire (ex. l'interaction avec d'autres composants, processus d'intégration au sein de l'ensemble du système, etc.). Elles portaient sur les connaissances architecturales (intégration du système) requises pour mettre ensemble tous les composants et former un système	☐	☐	☐	☐

51) Sur la base de votre expérience, laquelle des déclarations suivantes correspond le plus à votre point de vue sur le risque pris par la firme étrangère lorsqu'elle dispensait des formations sur le système satellitaire ?

Cochez la case appropriée

	Je suis en désaccord	Plutôt en désaccord	Plutôt en accord	Je suis en accord
Je crois que la formation dispensée était sur une technologie qui a été exploitée jusqu'à ses limites et peut être transférée sans risque (ex. risque d'alimenter une concurrence future, considérations sécuritaires).	☐	☐	☐	☐
Je crois que la technologie était avancée, mais la formation dispensée n'était pas assez profonde pour constituer un risque pour la société étrangère (ex. risque d'alimenter une concurrence future, considérations sécuritaires).	☐	☐	☐	☐
Je crois que la technologie était avancée, mais la société étrangère considérait que les capacités algériennes n'étaient pas assez avancées pour faire usage d'une technologie avancée.	☐	☐	☐	☐

C. Activités après le projet

52) Combien de personnes de votre équipe ont quitté votre organisation après le projet? Indiquez s'ils ont quitté le pays.

53) Avez-vous entretenu des relations avec le personnel de la compagnie étrangère après le projet? Si oui, est-ce que ces relations sont formelles ou informelles, de courtoisie ou professionnelles?

54) Avez-vous organisé ou été impliqué dans des ateliers post-projets ou des rencontres visant à étudier et consigner l'expérience et les leçons tirées du projet? Décrivez l'événement, les objectifs, les participants, les résultats, etc.

55) Au cours de vos activités après ce projet, avez-vous été impliqué dans des développements de technologie satellitaire?

- Décrivez vos activités dans le cadre d'autres projets satellitaires avec des compagnies étrangères (Alsat-2A, Alsat-2B, Alsat-1B, etc.)

- Décrivez vos activités en dehors des projets satellitaires avec des compagnies étrangères (activités locales, etc.)

56) Dans le cadre de vos activités liées aux technologies satellitaires en Algérie, en dehors des projets (Alsat-2A, Alsat-2B, Alsat-1B), quels étaient les buts et objectifs de vos activités?

57) Comment les objectifs ont été définis? Qui les a définis?

a/ Si les objectifs ont été définis par vous, est-ce qu'ils ont été discutés et approuvés par d'autres niveaux supérieurs de management? Quels sont ces niveaux? Est-ce que ces objectifs se complémentent avec d'autres objectifs?

-Comment avez-vous trouvé la clarté de ces objectifs?

Encerclez le nombre approprié

J'ai trouvé les objectifs						
Pas clairs						clairs
	1	2	3	4	5	

- Comment avez-vous trouvé la complexité de ces objectifs ? Considérant que la complexité est une combinaison de: -Nombre de composants à développer/personnaliser pour atteindre l'objectif, -Nombre de compétences (diversité) nécessaires pour le projet, -Nouvelles connaissances nécessaires pour le projet.

Encerclez le nombre approprié

La complexité des objectifs est						
Basse						Haute
	1	2	3	4	5	

- Comment avez-vous trouvé le risque associé à ces objectifs?

Encerclez le nombre approprié

Le risque associé aux objectifs est						
Bas						Haut
	1	2	3	4	5	

-Est-ce que ces objectifs sont flexibles en termes de spécifications (liberté d'ajuster les spécifications ou de revoir complètement les objectifs)?

Encerclez le nombre approprié

La flexibilité des objectifs en termes de spécifications est						
Basse (flexibilité)						Haute (flexibilité)
	1	2	3	4	5	

-Est-ce que ces objectifs sont flexibles en termes de financement (liberté de demander plus d'argent)?

Encerclez le nombre approprié

La flexibilité des objectifs en termes de financement est					
Basse (flexibilité)					Haute (flexibilité)
1	2	3	4	5	

-Est-ce que ces objectifs sont flexibles en termes de délais (liberté d'aller au-delà des délais)?

Encerclez le nombre approprié

La flexibilité des objectifs en termes de délais est					
Basse (flexibilité)					Haute (flexibilité)
1	2	3	4	5	

-En général, comment avez-vous trouvé l'ambition de ces objectifs ?

Encerclez le nombre approprié

J'ai trouvé les objectifs					
Pas ambitieux					Ambitieux
1	2	3	4	5	

-Comment avez-vous l'habitude de rapporter (et donner des feedbacks) sur les travaux relatifs à ces objectifs? À quelle fréquence? à qui?

45-b/ Si les objectifs sont définis ailleurs, où exactement? A quel niveau de management? Est-ce que ces objectifs se complémentent avec d'autres objectifs?

-Comment avez-vous trouvé la clarté de ces objectifs?

Encerclez le nombre approprié

J'ai trouvé les objectifs					
Pas clairs					clairs
1	2	3	4	5	

- Comment avez-vous trouvé la complexité de ces objectifs ? Considérant que la complexité est une combinaison de: -Nombre de composants à développer/personnaliser pour atteindre l'objectif, -Nombre de compétences (diversité) nécessaires pour le projet, -Nouvelles connaissances nécessaires pour le projet.

Encerclez le nombre approprié

La complexité des objectifs est					
Basse					Haute
1	2	3	4	5	

- Comment avez-vous trouvé le risque associé à ces objectifs?

Encerclez le nombre approprié

Le risque associé aux objectifs est					
Bas					Haut
1	2	3	4	5	

-Est-ce que ces objectifs sont flexibles en termes de spécifications (liberté d'ajuster les spécifications ou de revoir complètement les objectifs)?

Encerclez le nombre approprié

La flexibilité des objectifs en termes de spécifications est				
Basse (flexibilité)				Haute (flexibilité)
1	2	3	4	5

-Est-ce que ces objectifs sont flexibles en termes de financement (liberté de demander plus d'argent)?

Encerclez le nombre approprié

La flexibilité des objectifs en termes de financement est				
Basse (flexibilité)				Haute (flexibilité)
1	2	3	4	5

-Est-ce que ces objectifs sont flexibles en termes de délais (liberté d'aller au-delà des délais)?

Encerclez le nombre approprié

La flexibilité des objectifs en termes de délais est				
Basse (flexibilité)				Haute (flexibilité)
1	2	3	4	5

-En général, comment avez-vous trouvé l'ambition de ces objectifs ?

Encerclez le nombre approprié

J'ai trouvé les objectifs				
Pas ambitieux				Ambitieux
1	2	3	4	5

-Comment avez-vous l'habitude de rapporter (et donner des feedbacks) sur les travaux relatifs à ces objectifs? À quelle fréquence? à qui?

58) Combien de fois avez-vous rencontré (d'une manière formelle ou informelle) des hauts dirigeants de votre organisation afin de discuter sur ces objectifs? Qui étaient-ils? A quelle occasion et quel était le but des rencontres?

59) Quelle était votre motivation pour la réalisation de ces objectifs?

Encerclez le nombre approprié

Le niveau de ma motivation était				
Bas				Haut
1	2	3	4	5

-Pourquoi? Qu'est-ce qui vous motivait le plus, qu'est-ce qui vous motivait le moins?

60) En se basant sur votre expérience dans les satellites, comment la technologie évolue (vitesse de développement du système) et quelles sont les similitudes/différences entre les nouveaux systèmes (architecture, composants) par rapport aux anciens, et quelles sont les similitudes/différences dans leurs processus de développement? (réguliers/irréguliers, vitesse lente, vitesse élevée, trop élevée, des systèmes complètement différents, systèmes similaires, etc.). Donnez des indications sur les changements pour le cas des satellites algériens.

61) En ce qui concerne vos activités en Algérie qui sont liées aux systèmes satellitaires, est-ce que vous faite partie d'une équipe/projet ou votre activité est plutôt individuelle?

a/ Si vous faite partie d'une équipe/projet,

-Quelle est la taille de cette équipe/projet (nombre de personnel, spécialisation, leurs postes/positions, emplacement, leurs organisations/institutions, etc.)? Indiquez si les membres faisaient partie des projets satellitaires (avec des firmes étrangères) et indiquez lesquels?

-Si cette équipe implique plus d'une organisation/institution, est-ce que cette collaboration est encadrée par un accord explicite entre organisations ou bien elle est informelle? Quelles sont les compétences clés qui distinguent votre organisation des autres?

-Comment qualifiez-vous votre relation de travail avec les membres de l'équipe/projet ?

Encerclez le nombre approprié pour chaque membre

Intensité des relations	Formalité des relations	Difficulté des relations
Non-intenses (légères) — très intenses	Informelles (pas bien définies, flexibles) — Formelles (bien définies)	Faciles et pas conflictuelles — Difficiles et conflictuelles
1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

-Donnez plus de détails si nécessaire

-Décrivez la structure de l'équipe/projet. Est-ce que cette structure est appropriée pour des projets de satellites?

-Décrivez la documentation de management et les outils utilisés (système de suivi de calendrier et du budget, gestion des approvisionnements, gestion de la qualité, gestion des coûts, gestion des stocks, etc.). A quelle fréquence les membres de l'équipe/du projet utilisent ces outils? Parmi ces outils de management, est-ce qu'il y a des outils qui ont été déjà utilisés durant le projet satellitaire ave la firme étrangère (les mêmes outils ou des outils similaires)?

b/ Si votre activité est plutôt individuelle, avez-vous construit votre propre réseau d'individus / spécialistes/ universitaires (à l'intérieur ou l'extérieur de votre organisation) qui peuvent contribuer dans votre travail? (Nombre de personnes, spécialisation, positions/postes, organisations, etc.). Donnez des exemples.

62) En ce qui concerne vos activités en Algérie liées aux technologies satellitaires, Comment qualifiez-vous les performances de la fonction gestion des approvisionnements ?

63) En ce qui concerne vos activités en Algérie liées aux technologies satellitaires et aux connaissances que vous avez acquises durant le projet,

-Avez-vous bénéficié d'une formation qui est liée aux connaissances acquises durant le projet (ou les complète)? (Indiquez les formations en dehors de celles prévues dans le cadre des autres projets satellitaires)

-Est-ce que vous participez facilement à des séminaires et conférences liées aux technologies que vous avez managées durant le projet?

- Est-ce que vous accédez facilement aux informations sur les brevets liés aux technologies que vous avez managées durant le projet?

64) En ce qui concerne vos activités en Algérie liées aux technologies satellitaires et aux connaissances que vous avez acquises durant le projet, avez-vous formé, encadré, supervisé des gens dans votre organisation? Donnez des détails sur les stagiaires, combien de stagiaires? Pourquoi ils ont été formés? Combien de temps a duré la formation? Quel type de formation a été dispensé?

-Dans le cadre de ces mêmes activités, Est-ce que vous pouvez facilement recruter du personnel qualifié sur le marché du travail? Indiquez quelle est l'efficacité du processus de recrutement au sein de votre organisation (temps, anticipation, identification et ciblage des personnes qualifiées, etc.)?

65) Avez-vous dans votre organisation en Algérie une entité (département, etc.) en charge du management des projets de développement de satellites? Quelle est votre relation avec cette entité?

66) Indiquez vos activités en Algérie qui sont liées à, ou utilisent, des connaissances acquises durant le projet? Remplissez le tableau en considérant que:
- "Recherche" fait référence à la recherche fondamentale
- "Développement" fait référence à la traduction de connaissances techniques et scientifiques en produits, procédés et services
- "Engineering" fait référence à des aspects très pratiques

Catégories des activités	Exemples et description (précisez s'il s'agit d'une activité individuelle ou en équipe)
Recherche	
Développement	
Engineering	
Enseignement	
Autres	

67) Selon vous, quelle serait la part de vos activités liées au management de projets satellitaires, par rapport à toutes vos activités en Algérie?

Encerclez le nombre approprié

Les activités liées au management de projets satellitaires représentent						
une petite part du total de mes activités en Algérie						une grande part du total de mes activités en Algérie
	1	2	3	4	5	

68) En général, comment vous trouvé la nature de vos activités en Algérie? Remplissez le tableau en considérant que:
- "Recherche" fait référence à la recherche fondamentale
- "Développement" fait référence à la traduction de connaissances techniques et scientifiques en produits, procédés et services
- "Engineering" fait référence à des aspects très pratiques

Activités	Proportions		Donnez des exemples, explications et détails
Activités administratives	…….%		
Activités scientifiques	…….%	………% Recherche	
		………% Développent	
		………% Engineering	
		……..% Enseignement	
Autres	….%		

D. Suggestions finales

69) Selon votre expérience durant le projet, est-ce que l'objectif de développer des satellites similaires ou équivalents au niveau local serait raisonnable?

Encerclez le nombre approprié

Je trouve l'objectif de développer des satellites similaires ou équivalents au niveau local	
Non raisonnable	Très raisonnable
1 2 3 4 5	

-Pourquoi? Quels seraient les domaines de spécialisation (core competencies) et fonctions à développer localement, et ceux à importer de l'étranger?

70) Sur la base de votre expérience dans les technologies satellitaires, laquelle des déclarations suivantes correspond le plus à votre point de vue sur le début de développement de satellites au niveau local?

Cochez la case appropriée

	Je suis en désaccord	Plutôt en désaccord	Plutôt en accord	Je suis en accord
Je suggère de travailler avec des entreprises étrangères sur des technologies relativement anciennes, moins complexe, offrant des performances système relativement modestes ou faibles	☐	☐	☐	☐
Je suggère de travailler avec des entreprises étrangères sur des technologies relativement nouvelles, complexe, offrant des performances système relativement élevées	☐	☐	☐	☐
Je préférerais travailler **plus souvent** sur des technologies avec un risque d'échec plus élevé (non-achèvement de projet ou défaillance du système) plutôt que de travailler **moins souvent** sur des technologies avec un risque d'échec moindre	☐	☐	☐	☐

71) Selon vous, est-ce que votre organisation est favorable à prendre des risques lorsqu'il s'agit de développer des satellites au niveau local?

Encerclez le nombre approprié

Je trouve que mon organisation est plutôt	
favorable à prendre des risques	Non favorable à prendre des risques
1 2 3 4 5	

-Pourquoi ?

72) Quelle est votre motivation actuelle pour prendre part au développement de satellites au niveau local?

Encerclez le nombre approprié

Le niveau de ma motivation est	
Bas	Haut
1 2 3 4 5	

-Pourquoi?

73) Est-ce que vous êtes confiant de vos aptitudes actuelles pour manager des projets de développement de satellite au niveau local?

Encerclez le nombre approprié

Ma confiance dans mes aptitudes actuelles est	
Basse	Haute
1 2 3 4 5	

-Pourquoi?

74) Êtes-vous satisfait de votre parcours professionnel (développement de carrière) dans votre organisation?

Encerclez le nombre approprié

S'agissant du développement de ma carrière, ma satisfaction est	
Basse	Haute
1 2 3 4 5	

-Pourquoi?

75) En général, comment trouvez-vous l'environnement au sein de votre organisation pour votre travail et le développement de vos activités?

Encerclez le nombre approprié

Je trouve l'environnement au sein de mon organisation						
Non favorable						Très favorable
	1	2	3	4	5	

-Pourquoi?

76) En général, comment trouvez-vous l'environnement national pour votre travail et le développement de vos activités?

Encerclez le nombre approprié

Je trouve l'environnement national						
Non favorable						Très favorable
	1	2	3	4	5	

-Pourquoi?

77) Est-ce que vous êtes confiant du processus de développement de petits satellites en Algérie?

Encerclez le nombre approprié

S'agissant du développement local, ma confiance est						
Basse						Haute
	1	2	3	4	5	

-Pourquoi?

Appendix 2-a: Questionnaires for representatives from ASAL's entities (English version)

Date:	Participant ID:

Questions on building small satellite capabilities in Algeria

addressed to representatives of entities involved in the process

Research aim: To collect data in order to gain better understanding of satellite technology transfer to Algeria. This will enable Algerians to gain an appreciation on the effectiveness of the mechanisms that they have used to build satellite technological capabilities, and will provide guidance regarding effective processes to transfer satellite technology.

Guidance in responding to questions:

- The researcher will be interviewing you by himself in a face-to-face meeting to ensure proper understanding of questions and responses.
- Please feel free to use Arabic, French or English when responding.
- Feel free to include any oral or written comments, or material deemed relevant or supportive to your responses.
- All responses will be treated as confidential with only the researcher having access to them.

Sections covered:

A. General information
B. Learning effort
C. Capability-building management
D. Technology transfer management
E. Final suggestions

A. General information

1) What is your current position and describe your responsibilities and duties within your organisation? How long have you been in this position? How long have you been in this organisation?

2) Describe your missions (roles) with regard to the development of small satellite technology? Do you have an explicit (written) policy and strategy with regard to small satellite development (or remote sensing small satellite development)?

3) One of the stated goals of the Algerian space programme is to progressively develop satellite capabilities. The successive collaborative projects with foreign partners (e.g. Alsat-1, Alsat-2A, Alsat-2B, Alsat-1B) have been used as a mechanism, what are the targeted progressive phases? Are these targets explicitly formulated and are timelines defined?

4) In your view, what was the priority when successive satellite collaborative projects with foreign partners (Alsat-1, Alsat-2A, Alsat-2B, Alsat-1B) were used: the acquisition of satellite systems and their deployment for meeting national needs in terms of satellite images and applications, or learning how to develop satellites (completely or partially)?

5) How clear you find these objectives when it comes to implementing them?

6) How flexible are these objectives in terms of: a) specification (freedom to adjust specifications or to completely review objectives); b) funding (freedom to ask more money); and c) time (freedom to go beyond the agreed timeline)?

7) How risky do you find these objectives?

8) How ambitious do you find these objectives?

9) In your view, what motivates people the most to join your organisation and partake in developing satellite technology?

B. Learning effort

10) With regard to small satellite projects, in your view, which activity for each satellite project was given the most emphasis: Design, Project management, Systems engineering, System integration, or Operations? What are the areas targeted for learning and development by your organisation?

11) With regard to satellite technology, what are the areas of training and research targeted by your organisation (e.g. Space instrumentation, Space telecommunications and computing, Image processing and GIS, optics and precision mechanics, Space telecommunications, etc.)?

12) How these areas of specialisation have been defined? Were they defined according to ASAL's needs and priorities? Were they defined according to the national available capabilities?

13) What are the shares for each area of specialisation in the training and research effort? (e.g. number of students in masters, doctorate, number of projects, shares of funding, etc.). What is the share of satellite technology-centred areas compared to space application-centred areas?

14) What are the mechanisms and institutions used to carry out the training and research activities? (e.g. EDTAS, internal centres -CTS, CDS-, local universities and institutes, foreign cooperation, satellite collaborative projects Alsat-1, 2, etc.). What would be the share of each mechanism in this training and research effort?

15) How are satellite project management experiences and lessons learnt stored? How is documentation and knowledge acquired throughout collaborative projects or produced internally managed (gathered,

recorded, stored in DB, diffused locally, updated, computer-aided information system etc.)? Describe the strategy adopted and the mechanisms that have been put in place?

16) How are research projects identified or defined, conducted, funded, and managed?

17) To what extent are individuals involved in these research projects kept working on similar tasks and activities in Algeria? Describe whether mechanisms are put in place to ensure that this happens? What is ASAL's role in employing these individuals and making use of these project results?

18) What are the mechanisms used to ensure that individuals involved in satellite collaborative projects are involved in activities of training and research in Algeria in order to share their knowledge?

19) Satellite technology development involves multiple disciplines, which are the disciplines to develop in high priority and those considered of lower priority? (e.g. what about structural mechanics and space mechanics, power and energy, propulsion, system engineering, technology and satellite project management, system engineering, etc.)

20) In your view, what were the main contributions of the successive satellite projects (Alsat-1, Alsat-2A, Alsat-2B, Alsat-1B)?

21) What are the disciplines that you are seeking to develop in terms of small satellite technology? Indicate whether the objective is to develop components of satellite systems; develop capabilities to integrate small satellites from components developed elsewhere, or a mixture of the two? If the mixture is targeted, what would be the right balance between components knowledge and integrative knowledge? and which components would be developed as a priority and why?

22) How would you describe interactions between project teams (intense, formal, informal, framed, etc.)? and how interaction and communication between teams or entities in your organisation are fostered?

23) One of the goals of the Algerian space programme is to develop capabilities to integrate satellites. What would be the role of training, R&D in developing integrative knowledge (technology management, system engineering, etc.)

24) In your view, what were the main contributions of the successive satellite projects, components knowledge or integrative knowledge?

25) What are the actions undertaken in order to foster and develop integrative knowledge (training, communication, flat project structure, organisational entities such as system engineering departments, etc.)

26) How do you find the labour market when it comes to recruiting personnel for satellite development? How do you identify your needs? How are the personnel selected? How early on do you anticipate the projects' needs (e.g. forming a reservoir and recruiting internally when required, etc.)? To what extent do you envisage recruiting from the international labour market (Algerian abroad or foreigners)?

27) What is the impact on the skills (i.e. skills of Engineering, R&D) of the personnel involved when partaking in collaborative projects? In your view, how close is their knowledge to that required for developing satellites locally? Do you have any feedback on their skills with regard to work requirements or/and satellite development?

28) To what extent are/were individuals trained (or having conducted R&D activities) as part of other mechanisms (e.g. EDTAS, universities, etc.) involved in satellite collaborative projects?

For developing technological capabilities, three activities are often jointly fostered: Research, Development and Engineering, wherein:

- "Research" refers to basic research
- "Development" refers to translating technical and scientific knowledge into products, processes, and services
- "Engineering" refers to very practical aspects

29) What is the strategy for developing "Research", "Development", and "Engineering" activities in your organisation (training, skills development, objectives, organisation in charge, management, control, incentives towards people, etc.) and what are the actions undertaken? How are these activities defined and how relevant are they to the needs of small satellite development? Who are the actors in charge of Research promotion, Development promotion, and Engineering development with regard to satellite technology?

30) Considering your context, how important is each of these activities (i.e. Research, Development, and Engineering) for your organisation objectives? And what about human resources available in your organisation for each of these activities? What would be the proportions of these activities in your organisation?

31) What are the actions undertaken for fostering the links Research-Development-Engineering and vice-versa? How the R&D activities are commercialised? What are the achievements with regards to each activity (e.g. patents, commercialised products, etc.)? Do you have mechanisms that manage and combine the outputs to the satellites development needs? To what extend their outputs meet satellite development needs?

32) With regard to the activities of Research, Development, and Engineering, indicate achievements that stem mainly from small satellite collaborative projects? In your view, where was the learning effort focused (Engineering, development, or Research)? How was the learning effectiveness assessed?

33) Considering your context, how important is each of these activities (i.e. Research, Development, and Engineering) to your organisation objectives? And what human resources are available in your organisation for each of these activities? What would be the proportions of these activities in your organisation?

34) In general, universities develop fundamental research whereas applied aspects are developed within specialised research and development centres as well as industry development centres? To what extend is this true for satellite technology in Algeria? Is industry involved in this research? Is there any strategy towards the development of clusters in satellite technology?

35) What is the strategy for developing an indigenous Engineering sector able to provide the skills needed for satellite development and/or integration?

36) With regard to satellite local development, what are the objectives and strategy in terms of core-competencies to develop internally and elements to outsource (locally in Algeria)? In your view, which core competencies and functions could be developed within your organisation, which could be developed locally in Algeria but outside your organisation, and which could be imported from foreign firms? What would be the role of the industrial sector and the private sector in each instance? Are these objectives explicit? Do you have an entity in charge of managing the organisational network and related interaction?

37) With regard to research and development activities, does your organisation have an entity that carries out a technology watch (e.g. scientific and technological publications, seminars, patents analysis)?

38) In your organisation, how is small satellite technology development managed? and particularly how are small satellite projects managed? Are there permanent entities (or teams) in charge of these activities? Describe the organisational structure of these activities. How does the organisation get feedback and

control the progress of small satellite technology development in general and small satellite collaborative projects in particular? (Structural reviews, unstructured reviews, casual interactions, etc.).

39) What is the organisational strategy or mechanism that fosters intra-organisation and inter-organisation communication?

40) Does your organisation have a “formal” mechanism that identify, follow-up and manage experienced individuals and skilled individuals that stood out from the rest (e.g. they hold tacit knowledge, practical skills, theoretical skills, communication skills, etc.)? Does your organisation have a specific strategy in order to manage human resources that have been involved in successive collaborative projects (e.g. career plan, etc.)?

41) How is training planned within your organisation (according to expressed needs, by anticipations, etc.) and how is it controlled and assessed? Describe the process for activities related to Research, Development and Engineering.
-What about continuous training?
-What about Managerial training?
-What about communication skills development?

42) Does your organisation face an imbalance between personnel demand or “desire” and the offer in terms of positions in activities of Research, Development, or Engineering? How is managed the imbalance between the personnel interest and organisation’s goals?

43) How do you describe interactions between satellite project teams (intense, formal, informal, framed, etc.)? What is the organisation strategy or mechanism that fosters inter-team and intra-organisation communication and work (satellite project teams, entities within your organisation)? (Activities and projects that involve multiple teams, cooperation and exchange between teams, meetings, workshops, cross-functional objectives, etc.). Do you have any information system that enables group work, workflow, project management, scheduling, shared DB, etc.? Provide description with regard to Research activities, Development activities, and Engineering activities.

44) With regard to EDTAS activities, how do you describe interactions between EDTAS’ researchers and ASAL’s personnel (intense, formal, informal, framed, etc.)? (Joint project, joint research, joint publication, etc.). Indicate whether researchers who participated in satellite projects (Alsat-1, Alsat-2A, Alsat-2B, Alsat-1B) are involved in these exchanges?

45) How would you describe interactions between EDTAS’ researchers themselves, and between various universities involved (intense, formal, informal, framed, etc.)? (Joint project, joint research, joint publication, etc.)

C. Capability-building management

46) How appropriate are the equipment and facilities that have been built by your organisation (and its local partners) for conducting R&D activities in satellite technology?

47) What is the number of employees in your organisation? Estimate the proportions of the workforce involved in: Management, Operations, R&D, and Engineering.

48) How appropriate are the human resources of your organisation for conducting R&D activities in satellite technology? (Teams’ sizes, teams’ disciplines, team’s motivations, teams’ skills, etc.)

49) How appropriate are the equipment and facilities that have been built for the following missions: Satellite specification and design, components procurement, customisation and development, Assembly, test, operations?

50) How appropriate are the current human resources for the following missions: Satellite specification and design, components procurement, customisation and development, Assembly, test, operations? What are the human resources that are most needed to meet the organisation objectives?

51) How appropriate are the current managerial and organisational capabilities of your organisation for the requirement of developing small satellites? (Management skills might include: project structure, system of monitoring of schedules and budget, supply management, quality management, etc.)?

52) What is the number of employees in your organisation? Estimate the proportions of the workforce involved in: Management, Operations, R&D, and Engineering.

53) How do you qualify the contribution of the successive collaborative satellite projects in building technical skills vs managerial skills of personnel?

54) In parallel to the development of human resources through collaborative projects, what are the other actions undertaken in order to develop technical and managerial skills in manufacturing satellite components or integrate systems?

55) In your organisation, how is small satellite technology development managed? and particularly how are small satellite projects managed? Are there permanent entities (or teams) in charge of managing satellite development projects? Describe the organisational structure of these activities. How does the organisation get feedback and control the progress of small satellite technology development in general and small satellite collaborative projects in particular? (Structural reviews, unstructured reviews, casual interactions, etc.).
-What about the adoption of management tools particularly those related to satellite development? (e.g. system of monitoring of schedules and budget, supply management, quality management, cost management, stock management, etc.).

56) How appropriate you find your current organisation structure to the requirement of developing small satellites?

57) How appropriate you find the procurement and supply procedure to the requirement of developing small satellites?

58) Does your organisation deploy a quality assurance approach (e.g. Total quality management practices aiming to continuous improvement, etc.)? Do you have an entity in charge of quality management?

59) The local environment is poor in terms of organisations and firms (suppliers, sub-contractors, R&D institutions) working on satellite technology, What are the objectives and strategies adopted for putting in place this environment and for encouraging actors to join you? What are the actions taken for this purpose (identifying them, surveying them, training them, transferring technology to them, helping them upgrading their facilities, incentives, etc.)? Do you have a dedicated entity or an organisation to oversee this process?

60) Do you have an entity in charge of promoting and managing the organisational network (and related interactions) for the purpose of developing small satellite technologies at Research, Development, and Engineering level?

D. Technology transfer management

61) Collaborative projects are a mechanism that has been used for the last 15 years by your organisation to develop satellite technological capability? In your view, how is this mechanism evaluated, what are its strengths and weaknesses, and to what extent has it met Algerian needs and complied with Algerian objectives?

62) Irrespective of small satellite collaborative projects, how do you qualify your international collaboration related to the development of small satellite technology? Do you make use of other international

mechanisms to develop this technology? (collaborations on Research projects, Development projects, Engineering projects) (Use of unconventional mechanisms through offering incentives to foreign investors – Foreign Direct Investment, etc.)

63) In general, diversifying partners at international level can increase opportunities for technology transfer and overcome certain setbacks. To what extent does this apply to small satellite development in Algeria?

64) In your view, what is the strategy used to incentivise the foreign partners to be more effective in transferring technology? To what extent have the previous contracts been representative of this strategy (were the incentives in those contracts appropriate)?

65) Based on your experience, which of the following statements matches your view most closely in terms of the risk the foreign company was taking when it provided training or transferred technology on the satellite?
   a-The foreign companies considered that the transferred technology has been exploited up to its limits and can be transferred without any risk (e.g. risk of fuelling future competition, security considerations).
   b- The foreign companies considered that transferred technology was advanced but the training provided was not deep enough to be risky for them (e.g. risk of fuelling future competition, security considerations).
   c-The foreign companies considered that technology was advanced, but they consider the Algerian's capabilities are deemed to be not well enough advanced to make use of the advanced technology.

66) ASAL used satellite collaborative projects with foreign companies as mechanism for transferring technology from abroad. Considering the level reached of local capabilities and limitations of collaborative projects mechanism to go further, does ASAL envisage adopting new mechanisms (e.g. Licence production, relocation of foreign company activities, use of FDI-Foreign Direct Investment, etc.) for achieving higher levels of capabilities?

67) What kind of relationship do you usually have with your foreign partners after the projects? Are these relations maintained through formal agreements? are they intense? How do they evolve?

68) As technology transfer from abroad is an important way for developing satellite technology in Algeria, and in either technology transfer relationship or technology intensive industries, managing intellectual property issues (e.g. patents, etc.) is important for protecting foreign partners' intellectual property and local innovation effort. How are these issues managed in your organisation? Does your organisation have an entity that manages intellectual property issues?

69) How would you describe your current international experience in small satellite project negotiations, what about the negotiation balance and your bargaining power?

70) Did local partners (universities, industry, EDTAS, etc.) benefit from the collaboration with ASAL in order to train their human resources for acquiring new skills, to update their equipment and facilities for Research, Development and Engineering, or to adapt their organisation for new requirements related to satellite development? Do you have a technology transfer programme or mechanism towards local partners?

71) In your view, what is the strategy that ASAL should adopt to incentivise local partners to be effectively involved in ASAL's satellite development activities?

72) How would you describe the international collaboration of EDTAS with regard to R&D on satellite technology?

E. Final suggestion

73) How would you describe the needs of both local and international markets in terms of small satellite technology (components and systems market)? How would you describe the trend of small satellite markets (whether it evolves to suppliers markets, buyers markets, etc.)?

74) According to your experience, do you have other market technological needs that can be met by using the satellite capabilities under development and the knowledge acquired? (e.g. automotive, aeronautic, medical technologies, etc.) Are you envisaging addressing these markets?

75) Algeria's policy throughout the last two decades has promoted an active sector of satellite image applications, what are the local trends in terms of growth and are/will needs be met? In your view, how would the market best be balanced between demand (of satellite images) and offer (satellite systems)? Do the planned/realised satellite systems meet the need?

76) With regard to satellite images, what is (would be) the targeted market: local, regional, or international?

77) With regard to small satellite components and systems, what is (would be) the targeted market, local, regional, or international?

78) How would you describe the local effort to develop small satellites? Is there more emphasis on the market development (users of satellite images, etc.) or satellite system development?

79) In your view, what is (would be) the guidance for Algerian efforts for developing small satellites: to develop (components and systems) for import substitution, or to develop for export to international market?

80) In your view, for developing small satellites, what would be the core competencies and functions to develop within your organisation, to develop locally in Algeria but outside your organisation, and to import from foreign firms?

81) With regard to small satellite projects, in your view, what would be the emphasis of your work and tasks: Design, Project management, Systems engineering, System integration, or Operations?

82) Based on your experience on satellite technology and your knowledge of the local context, what would you suggest is most important in order to start developing satellites locally?
   a- to work with foreign firms on relatively old, less complex technology providing relatively modest or low system performances
   b- to work with foreign firms on relatively new, complex technology providing relatively high system performances
   c- to work **more often** on technology with higher risk of failure (non-completion or system failure) rather than working **less often** on technology with lesser risk of failure

83) How confident do you feel about your organisation's ability in order to develop small satellites locally?

84) How would you describe the national policy in terms of Research, Development and Engineering promotion and its impact on satellite technology? How would you describe the intensity (e.g. investment, etc.) and outputs of these activities? Are they towards basic research, applied aspects, or more practical aspects?

   -How would you describe the national science and technology environment (science and technology policy, R&D policy, regulations, etc.) and its impact on satellite technology? How would you describe the intensity (e.g. investment, etc.) of activities in this environment and their relationships to satellite technology development? Within this environment, are actions promoted towards basic research, applied aspects, or more practical aspects?

   -How would you describe the national industrial environment (industrial policy, high technology industry policy, innovation policy, regulation, etc.) and its impact on satellite technology development? How would you describe the intensity (e.g. investment, etc.) of activities in this environment and their relationships to satellite technology?

   -How would you describe the national economic context (e.g. markets, regulations, protection measures, funding systems, etc.) and its impact on satellite technology development?

-How do you qualify the leadership evolution of the space sector at national level (from an entity under the PM (Prime Minister, formerly known as Chief of Government), then under MPTIC (Ministry of Post and Information and Communications Technologies), then again under PM)? To what extent did the changing in leadership affect the progress of this sector?

85) The socio-economic objectives are part of the space programme objectives in Algeria, are nation inspiration, nation pride and confidence building amongst people explicitly part of these objectives?

Appendix 2-b: Questionnaires for representatives from ASAL's entities (French version)

Date:	Participant ID:

Questions sur la mise en place de capacités de développement de petits satellites en Algérie

adressées aux représentants des entités impliquées dans ce processus

Objectifs de la recherche: Recueillir des données qui permettent de mieux comprendre le processus de transfert des technologies satellitaires pour le cas de l'Algérie. Cela permettra aux Algériens d'avoir une appréciation sur l'efficacité des mécanismes qu'ils utilisent pour mettre en place un potentiel de développement des technologies de petits satellites, et fournira des indications sur les processus les plus efficaces à adopter pour transférer les technologies satellitaires.

Orientations pour répondre aux questions:

- Le chercheur lui-même vous interviewera (face-à-face) lors d'une réunion, à convenir, pour s'assurer de la bonne compréhension des questions et de la bonne formulation des réponses.
- Utilisez, à votre convenance, l'arabe, le français ou l'anglais au moment de répondre.
- Vous pouvez faire, à votre convenance, des commentaires, oraux ou écrits, et joindre tout document que vous estimeriez pertinent.
- Toutes les réponses seront traitées de manière confidentielle. Seul le chercheur aura accès à ces réponses.

Sections couvertes:

A. Informations générales
B. Effort d'apprentissage
C. Management du développement des capacités
D. Management du transfert des technologies
E. Suggestions finales

A. Informations générales

1) Quelle est votre poste/position actuel ? et décrivez vos responsabilités et fonctions au sein de votre organisation? Combien de temps avez-vous passé dans ce poste/position? Combien de temps avez-vous passé dans cette organisation?

2) Décrivez vos missions par rapport au développement des technologies des petits satellites? Est-ce que vous avez une politique/stratégie explicite (écrite) en matière de développement de petits satellites (ou le développement des petits satellites de télédétection)?

3) L'un des buts déclarés du programme spatial algérien est de développer en phase et progressivement des capacités satellitaires. Les projets collaboratifs successifs avec des partenaires étrangers (ex. Alsat-1, Alsat-2A, Alsat-2B, Alsat-1B) ont été utilisés comme mécanisme. Quelles sont ces phases progressives ciblées ? Est-ce que ces cibles sont formulées explicitement et est-ce que des calendriers leur sont définis?

4) Selon vous, quelle a été (serait) la priorité lors de l'usage de projets collaboratifs de satellites successifs avec des partenaires étrangers (Alsat-1, Alsat-2A, Alsat-2B, Alsat-1B): l'acquisition de systèmes satellitaires et leur déploiement pour répondre aux besoins nationaux en termes d'images satellitaires et d'applications, ou apprendre à développer des satellites (totalement ou partiellement)?

5) Comment trouvez-vous ces objectifs en termes de clarté lorsqu'il s'agit de les mettre en œuvre (les traduire en actions)?

6) Comment qualifiez-vous la flexibilité de ces objectifs en termes de spécifications (liberté d'ajuster les spécifications ou revoir complètement les objectifs) ? en termes de financement (liberté de demander plus d'argent) ? en termes de délais (liberté d'aller au-delà des délais) ?

7) Comment qualifiez-vous le risque associé à ces objectifs?

8) Comment qualifiez-vous l'ambition de ces objectifs?

9) Selon vous, qu'est-ce qui motive le plus les gens à se joindre à votre organisation et à participer au développement des technologies satellitaires ?

B. Effort d'apprentissage

10) Pour chacun des projets de petits satellites, selon vous, sur lesquelles des aspects suivants l'accent a été mis : Conception, gestion de projet, l'ingénierie des systèmes, l'intégration du système, ou les opérations? quels sont les domaines de formation et développement ciblés par votre organisation?

11) S'agissant des technologies satellitaires, quels sont les domaines de formation et de recherche ciblés par votre organisation (e.g. instrumentation spatiale, télécommunications spatiales, applications spatiales, etc.)

12) Comment ces domaines de spécialisation ont été définis? Ont-ils été définis en fonction des besoins et des priorités de l'ASAL? Ont-ils été définis en fonction des capacités disponibles au niveau national?

13) Quels sont les parts de chaque domaine de spécialisation dans l'effort de formation et de R&D? (le personnel affecté, le nombre d'étudiants en masters, doctorants, nombre de projets, parts de financement, etc.). Quel est la part des domaines orientés vers les technologies satellitaires comparé aux domaines orientés vers les applications spatiales ?

14) Quels sont les mécanismes et les institutions utilisés pour mener les activités de formation et de recherche? (ex. EDTAS, centres internes -CTS, CDS-, les universités et les instituts locaux, coopération internationale, projets satellitaires collaboratifs Alsat-1, 2, etc.) ? Quelle serait la part de chaque mécanisme dans cet effort de formation et de recherche?

15) Comment les expériences de gestion des projets satellitaires et les enseignements tirés sont stockés? Comment la documentation et les connaissances acquises à travers les projets collaboratifs ou produites en interne sont gérées (recueillies, enregistrées, stockées dans des bases de données, diffusé localement, mis à jour, système d'information assistée par ordinateur, etc.)? Décrivez la stratégie adoptée et les mécanismes mis en place?

16) Comment les projets de recherche sont identifiés et définis, menées, financés, et gérées?

17) Dans quelle mesure les individus impliqués dans ces projets de recherche sont tenus de travailler en continue sur des activités et des tâches similaires ou reliées? Décrivez si des mécanismes sont mis en place? Quel est le rôle de l'ASAL dans l'emploi de ces individus et dans l'utilisation des résultats de ces projets ?

18) Quels sont les mécanismes utilisés pour assurer que les individus impliqués dans des projets collaboratifs de satellites (Alsat…etc.) soient impliqués dans des activités de formation et de recherche en Algérie afin qu'ils partagent leurs connaissances?

19) Le développement des technologies de petits satellites implique plusieurs disciplines, quelles sont les disciplines à développer en première priorité et celles de priorités moindres? (ex. qu'en est-il de la mécanique des structures et de la mécanique spatiale, énergies, propulsion, management de la technologie et des projets satellitaires, ingénierie des systèmes, etc.)

20) Selon vous, quelles ont été les principales contributions des projets successifs de satellites (Alsat-1, Alsat-2A, Alsat-2B, Alsat-1B)?

21) Quelles sont les disciplines que vous ciblez dans les technologies des petits satellites à développer? Indiquez si les objectifs sont de développer des composants de systèmes de satellites; développer des capacités à intégrer de petits satellites à partir de composants développés ailleurs, ou un mélange? Si le mélange est ciblé, qu'est-ce qui serait le bon équilibre entre les connaissances à acquérir sur les composants et les connaissances à acquérir sur l'intégration (connaissances intégratives)? et quels composants seraient développés en priorité et pourquoi?

22) Comment qualifiez-vous les interactions entre les équipes de projet (intense, formel, informel, encadré, etc.)? et comment l'interaction et la communication entre les équipes ou les entités de votre organisation sont encouragées?

23) L'un des objectifs du programme spatial algérien est de développer les capacités d'intégration des satellites. Quel serait le rôle de la formation, R&D dans le développement des connaissances intégratives (Management de la technologie, l'ingénierie des systèmes, etc.)

24) Selon vous, quelles ont été les principales contributions des projets successifs de satellites, des connaissances sur les composants, ou des connaissances sur l'intégration (connaissances intégratives)?

25) Quelles sont les actions entreprises en vue de promouvoir et de développer les connaissances intégratives (formation, communication, structure de projet plate, les entités organisationnelles telles que les services d'ingénierie du système, etc.)

26) Comment trouvez-vous le marché du travail en matière de recrutement de personnel à impliquer dans le développement des satellites? Comment identifiez-vous vos besoins? Comment le personnel est sélectionné? Est-ce que vous avez une stratégie d'anticipation en matière de besoins des projets (ex. pour la formation d'un réservoir et recruter en interne en cas de besoin, etc.)? Dans quelle mesure vous envisagez de recruter sur le marché international du travail (Algériens à l'étranger ou étrangers) ?

27) Quel est l'impact de la participation aux projets collaboratifs (Alsat-1, Alsat-2A, Alsat-2B, Alsat-1B) sur les compétences du personnel impliqué (compétences en Engineering, R&D)? Selon vous, comment trouvez-vous leurs compétences par rapport aux exigences de développement de satellites localement? Est-ce que

vous avec eu un feedback sur leurs compétences par rapport aux exigences d'emploi ou/et de développement de satellites?

28) Dans quelle mesure des individus formés (ou ayant mené des activités de R&D) par le biais d'autres mécanismes (ex. EDTAS, universités, etc.) ont été impliqués dans des projets collaboratifs de satellites?

Pour développer des capacités technologiques, trois activités sont souvent conjointement encouragées: la « Recherche », le « Développement » et « l'Ingénierie ou Engineering », où:

- "Recherche" fait référence à la recherche fondamentale
- "Développement" fait référence à la traduction de connaissances techniques et scientifiques en produits, procédés et services
- " Ingénierie ou Engineering" fait référence à des aspects très pratiques

29) Quelles sont les actions entreprises pour développer les activités de « Recherche », « développement », et « Engineering » dans votre organisation? (Formation, développement de compétences et d'habiletés, objectifs, organisation en charge, gestion, contrôle, incitations envers le personnel, etc.). Comment ces activités sont définies et comment sont-elles reliées aux besoins de développement de petits satellites? Quels sont les acteurs en charge de la promotion de la Recherche, du Développement, et de l'Engineering en matière de technologie des satellites?

30) Compte tenu de votre contexte, quelle est l'importance de chacune de ces activités (« Recherche », « Développement », et « Engineering ») pour les objectifs de votre organisation? Et qu'en est-il des ressources humaines disponibles dans votre organisation pour chacune de ces activités? Quelles seraient les proportions de ces activités dans votre organisation?

31) Quelles sont les actions entreprises pour favoriser les liens Recherche-Développement-Engineering et vice-versa? Comment les activités de R&D sont valorisées (et commercialisées) ? Quelles sont les réalisations pour ces activités (ex. Brevets, produits commercialisables, etc.) ? Avez-vous des mécanismes qui gèrent et relient les outputs aux besoins de développement des satellites? Dans quelle mesure ces outputs répondent aux besoins de développement de satellite?

32) S'agissant des activités de Recherche, Développement, et Engineering, indiquez les réalisations qui découlent principalement des projets collaboratifs de petits satellites? Selon vous, l'effort d'apprentissage fourni par votre organisation s'est concentré plutôt sur « l'Engineering », le « Développement », ou la « Recherche » ? Comment l'efficacité de cet apprentissage a été contrôlée?

33) Compte tenu de votre contexte, quelle est l'importance de chacune de ces activités (« Recherche », « Développement », et « Engineering ») pour les objectifs de votre organisation? Et qu'en est-il des ressources humaines disponibles dans votre organisation pour chacune de ces activités? Quelles seraient les proportions de ces activités dans votre organisation?

34) En général, les universités développent de la recherche fondamentale tandis que les aspects appliqués sont développés dans les centres de recherche et de développement spécialisés, ainsi qu'au niveau des centres de développement de l'industrie? Dans quelle mesure cela est vrai pour le cas de la technologie satellitaire en Algérie? Est-ce que l'industrie est impliquée dans la recherche? Y a-t-il une stratégie pour la mise en place de clusters (groupements) pour le développement de technologies satellitaires?

35) Quelle est la stratégie pour le développement d'un secteur local de l'Engineering en mesure de fournir les compétences nécessaires pour le développement et / ou l'intégration des satellites?

36) S'agissant du développement de satellites localement, quels sont les objectifs en termes de compétences clés (core-competencies) à développer en interne et les éléments à externaliser (localement en Algérie)? Quelles seraient les compétences clés et les fonctions de base à développer au sein de votre organisation, celles à développer localement en Algérie, mais en dehors de votre organisation, et celles à importer de l'étranger? Quel serait le rôle du secteur industriel et du secteur privé ? Est-ce-que ces objectifs sont

explicitement déclinés? Avez-vous une entité en charge de la gestion du réseau de l'organisation et des interactions?

37) S'agissant des activités de Recherche et de Développement, est-ce que vous avez une entité qui réalise une veille technologique (ex. l'analyse des publications scientifiques et technologiques, des séminaires, des brevets)?

38) Dans votre organisation, comment le développement des technologies de petits satellites est géré? et en particulier comment les projets de petits satellites sont gérés? Y at-il des entités permanentes (ou équipes) en charge de ces activités? Décrivez la structure organisationnelle de ces activités. Comment l'organisation obtient des feedback et contrôle la progression du développement des technologies des petits satellites et en particulier les projets collaboratifs de petits satellites? (revues structurelles ou planifiées, revues non structurelles et non planifiées, interactions informelles ou occasionnelles, etc.).

39) Comment qualifiez-vous la stratégie et les mécanismes adoptés par votre organisation pour favoriser la communication intra-organisationnelle et inter-organisationnelle?

40) Est-ce que votre organisation dispose d'un mécanisme «formel» qui identifie, suit et gère les personnels expérimentés et les individus qualifiés qui se démarquent du reste dans le développement des satellites (ex. ils détiennent des connaissances tacites, compétences pratiques, compétences théoriques, compétences de communication, etc.)? Est-ce que votre organisation a une stratégie spécifique pour gérer les ressources humaines qui ont été impliqués dans les projets collaboratifs successifs (ex. un plan de carrière, etc.)?

41) Comment la formation est planifiée au sein de votre organisation? (en fonction des besoins exprimés, par anticipations, etc.) et comment est-elle contrôlée et évaluée? Décrivez le processus pour les activités liées à la « Recherche », au « Développement » et à « l'Engineering ».
-Qu'en est-il de la formation continue?
-Qu'en est-il de la formation managériale?
-Qu'en est-il du développement des compétences en communication?

42) Est-ce que votre organisation rencontre des asymétries entre la demande du personnel ou leur «désir» en termes d'emploi, et l'offre en termes de postes à pourvoir dans les activités de Recherche, de Développement, ou d'Engineering? Comment ce compromis entre l'intérêt personnel et les objectifs de l'organisation est managé?

43) Comment qualifiez-vous les interactions et échanges entre les différentes équipes de projet (intense, formel, informel, encadré, etc.) ? Quelle est la stratégie (ou les mécanismes) de l'organisation pour favoriser la communication et le travail inter-équipe et intra-organisation (équipes de projet satellite, entité internes à votre organisation)? (Activités et projets qui impliquent plusieurs équipes, la coopération et les échanges entre les équipes, des réunions, des ateliers, des objectifs transversaux, etc.). Avez-vous un système d'information qui permet le travail de groupe, workflow, gestion de projet, planification, bases de données partagées, etc. ? Donnez des détails sur les activités de Recherche, de Développement, et d'Engineering.

44) S'agissant des activités de l'EDTAS, comment qualifiez-vous les interactions et échanges entre les chercheurs de l'EDTAS et le personnel de l'ASAL (intense, formel, informel, encadré, etc.) ? (projets conjoints, recherches conjointes, publications conjointes, etc.). indiquez si des chercheurs qui ont participé aux projets satellitaires (Alsat-1, Alsat-2A, Alsat-2B, Alsat-1B) sont impliqués dans ces échanges.

45) Comment qualifiez-vous les interactions et échanges entre les chercheurs de l'EDTAS, entre eux, et entre les différentes universités impliquées (intense, formel, informel, encadré, etc.) ? (projets conjoints, recherches conjointes, publications conjointes, etc.)

C. Management du développement des capacités

46) Est-ce que les équipements et installations mis en place par votre organisation (et ces partenaires locaux) sont appropriés pour la conduite d'activités de R&D dans les technologies satellitaires ?

47) Quel est le nombre d'employés dans votre organisation? Estimez la proportion de la main-d'œuvre impliquée dans: Management, Opérations, R & D et Engineering.

48) Est-ce que les ressources humaines de votre organisation sont appropriées pour la conduite d'activités de R&D dans les technologies satellitaires ? (Tailles des équipes, disciplines des équipes, motivations des équipes, compétences des équipes, etc.)

49) Est-ce que les équipements et installations mis en place par votre organisation (et ces partenaires locaux) sont appropriés aux missions suivantes : spécification et conception des satellites, achats de composants, personnalisation et développement, Assemblée, test, opérations?

50) Est-ce que les ressources humaines de votre organisation sont appropriées pour les missions suivantes: spécification et conception des satellites, achats de composants, personnalisation et développement, Assemblée, test, opérations ? Quelles sont les ressources humaines les plus requises pour atteindre les objectifs de l'organisation?

51) Est-ce que les capacités managériales et organisationnelles actuelles de votre organisation sont appropriées aux exigences de développement de petits satellites? (Les capacités managériales pourraient inclure: la structuration des projets, système de suivi des plannings et de budgétisation, gestion des approvisionnements, gestion de la qualité, etc.)

52) Quel est le nombre d'employés dans votre organisation? Estimez la proportion de la main-d'œuvre impliquée dans: R & D, Engineering, Management, Opérations.

53) Comment qualifiez-vous les contributions des projets successifs de satellites en matière de développement de compétences techniques vs compétences managériales du personnel?

54) Parallèlement au développement des ressources humaines par le biais des projets collaboratifs de satellite, quelles sont les autres actions entreprises dans le but de développer des compétences techniques et de management dans le domaine spécifique de la fabrication des composants de satellite ou de l'intégration de systèmes?

55) Dans votre organisation, comment est managé le développement des technologies de petits satellites? et en particulier comment sont managés les projets de petits satellites? Y a-t-il des entités permanentes (ou équipes) en charge de la gestion des projets de développement de satellites? Décrivez la structure organisationnelle de ces activités. Comment l'organisation est informée de l'évolution (feedback), et contrôle la progression, du développement des technologies de petits satellites en général, et les projets collaboratifs de petits satellites en particulier? (mécanismes et interactions formels, structurées, non structurées, plutôt informels, etc.).
-Qu'en est-il de l'adoption d'outils de gestion en particulier ceux liés au développement de satellites? (ex. structuration de projet, système de planification, de suivi des calendriers et du budget, chaine logistique et gestion des approvisionnements, gestion de la qualité, gestion des coûts, gestion des stocks, etc.).

56) Est-ce que vous trouvez que l'organisation actuelle de votre structure est appropriée aux exigences de développement de petits satellites?

57) Est-ce que vous trouvez que les procédures d'achats et d'approvisionnements sont appropriées aux exigences de développement de petits satellites?

58) Est-ce que votre organisation déploie une approche d'assurance qualité (ex. pratiques de management de la Qualité Totale visant l'amélioration continue, etc.)? Avez-vous une entité en charge de la gestion de la qualité?

59) L'environnement local est pauvre en termes d'organisations et d'entreprises (fournisseurs, sous-traitants, institutions de R & D) qui travaillent sur la technologie des satellites ; Quels sont les objectifs et les stratégies adoptées pour mettre en place cet environnement et pour encourager les acteurs à se joindre à vous? Quelles sont les mesures prises à cet effet (identifier les acteurs, les auditer, les former, transférer la technologie pour eux, les aider à mettre à niveau leurs installations, les mesures incitatives, etc.)? Avez-vous une entité ou organisation dédiée à cette mission?

60) Avez-vous une entité en charge de la promotion et la gestion du réseau d'organisations (et des interactions) dans le but de développer des technologies de petits satellites et ce aux niveaux de la « Recherche », du « Développement », et de « l'Engineering »?

D. Management du transfert des technologies

61) Les projets collaboratifs ont été utilisés comme mécanisme de développement de capacités technologiques satellitaires les 15 dernières années par votre organisation, comment évaluez-vous ce mécanisme, quelles sont ses points forts et ses points faibles, et dans quelle mesure il a répondu aux besoins et objectifs algériens?

62) Indépendamment des projets collaboratifs de petits satellites, comment qualifiez-vous votre collaboration internationale relative au développement des technologies des petits satellites? Utilisez-vous d'autres mécanismes internationaux pour développer cette technologie, pour former et pour mener des activités de R&D? (Collaborations sur des projets de Recherche, des projets de Développement, des projets d'Engineering) (utilisation de mécanismes non-conventionnels en offrant des incitations aux investisseurs étrangers - Investissement Etrangers Direct, etc.)

63) En général, la diversification des partenaires au niveau international peut accroître les possibilités de transfert de technologie et surmonter certains obstacles (dépendance), dans quelle mesure cela s'applique pour le développement des petits satellites en Algérie?

64) Selon vous, quelle est la stratégie utilisée pour inciter les partenaires étrangers pour être plus efficace dans le transfert des technologies? Dans quelle mesure les contrats précédents étaient représentatifs de cette stratégie (Est-ce que les mesures incitatives dans ces contrats étaient appropriées)?

65) Sur la base de votre expérience, laquelle des déclarations suivantes correspond le plus à votre point de vue sur le risque pris par la firme étrangère lorsqu'elle dispensait des formations ou transférait de la technologie sur les satellitaires ?
a- Les Entreprises étrangères ont estimé que la technologie transférée a été exploitée jusqu'à ses limites et peut être transférée sans risque (ex. risque d'alimenter une concurrence future, considérations sécuritaires).
b- Les sociétés étrangères ont estimé que la technologie transférée était avancée, mais la formation dispensée n'était pas assez profonde pour constituer un risque pour la société étrangère (ex. risque d'alimenter une concurrence future, considérations sécuritaires).
c- Les Entreprises étrangères ont estimé que la technologie était avancée, mais elles considéraient que les capacités algériennes n'étaient pas assez avancées pour faire usage d'une technologie avancée.

66) L'ASAL a utilisé les projets collaboratifs de satellites avec des entreprises étrangères comme mécanisme de transfert de technologie de l'étranger. Considérant le niveau atteint des capacités locales et des limitations des projets collaboratifs de satellites pour aller plus loin dans le transfert, est-ce que l'ASAL envisage l'adoption de nouveaux mécanismes (ex. Licence de production, délocalisation les activités d'entreprises étrangères, utilisation d'investissements directs étrangers IDE, etc.) pour des niveaux de réalisations plus élevés?

67) Quel genre de relations avez-vous généralement avec vos fournisseurs de satellites après le projet? Est-ce que ces relations sont entretenues par des accords formels, sont-elles intenses, etc.? Comment évoluent-elles?

68) Compte tenu du fait que le transfert de technologies de l'étranger est crucial pour le développement de technologies satellitaire, et compte tenu du fait que dans les relations de transferts de technologies et dans les industries à forte intensité technologique, la gestion des questions de propriété intellectuelle (ex. les brevets, etc.) est importante pour protéger la propriété intellectuelle des partenaires étrangers ainsi que l'effort d'innovation local. Comment ces questions sont gérées dans votre organisation? Est-ce que vous avez une entité qui gère les questions de propriété intellectuelle?

69) Comment qualifiez-vous votre expérience internationale actuelle dans la négociation des projets de petits satellites ? qu'en est-il de l'équilibre dans les négociations et qu'en est-il de votre pouvoir de négociation ?

70) Est-ce que les partenaires locaux (universités, industrie, EDTAS, etc.) ont bénéficié de la collaboration avec l'ASAL pour former leur ressources humaines et acquérir de nouvelles compétences, pour mettre à jour leurs équipements et installations pour mener des activités de Recherche, Développement, et Engineering, ou adapter leurs organisations aux nouveaux besoins liés au développement de satellites? Est-ce que vous avez un programme ou mécanisme de transfert de technologies envers les partenaires locaux ?

71) Selon vous, quelle est la stratégie que devrait adopter l'ASAL pour inciter les partenaires locaux à participer efficacement aux activités de l'ASAL en matière de développement de satellites?

72) Comment qualifiez-vous la collaboration internationale de l'EDTAS en matière de R&D portant sur la technologie satellitaire ?

E. Suggestions finales

73) Comment qualifiez-vous les besoins des marchés, local et international, en termes de technologie de petits satellites (marché des composants et des systèmes)? Comment qualifiez-vous la tendance dans les marchés des petits satellites (évolution vers des marchés dominés par les fournisseurs, des marchés dominés par des acheteurs, etc.) ?

74) Selon vous, avez-vous d'autres marchés dont les besoins technologiques peuvent être satisfaits en utilisant les capacités qui sont en cours de développement et les connaissances qui ont été acquises (ex. automobile, aéronautique, technologies médicales, etc.)? Est-ce que vous envisagez de vous adresser à ces marchés?

75) La politique de l'Algérie au cours des deux dernières décennies a promu le secteur des applications de l'imagerie satellitaire, quelles sont les tendances locales en termes de croissance et est-ce que les besoins sont/seront satisfaits? Selon vous, comment serait l'équilibre du marché entre la demande (des images satellites) et l'offre (des systèmes satellites)? Est-ce que les systèmes de satellites prévus / réalisés répondront aux besoins?

76) S'agissant du marché des images satellitaires, quel est (serait) le marché cible : local, régional, ou international ?

77) S'agissant du marché des composants et systèmes satellitaires, quel est (serait) le marché cible, local, régional, ou international ?

78) Comment qualifiez-vous l'effort national en matière de développement de petits satellites de télédétection, est-ce que cet effort a été plutôt tiré par le développement du marché (utilisateurs des images satellites, etc.) ou est-ce qu'il est plutôt poussé par le développement de systèmes satellitaires (développement de composants et de systèmes satellites)?

79) Selon vous, quel est (serait) la direction des efforts algériens dans le développement de petits satellites, est-ce vers le développement de composants et de systèmes favorisant le remplacement des importations, ou bien le développement de composants et de systèmes destinés à l'exportation vers le marché international?

80) Selon vous, pour développer de petits satellites, quelles seraient les compétences et les fonctions de base à développer au sein de votre organisation, ceux pour développer localement en Algérie, mais en dehors de votre organisation, et ceux d'importer des entreprises étrangères?

81) S'agissant des projets de petits satellites, selon vous, sur quoi l'accent devrait être mis dans vos travaux et taches: « la Conception », « la gestion de projet », « l'ingénierie des systèmes », « l'intégration du système », ou « les opérations »?

82) Sur la base de votre expérience dans les technologies satellitaires et votre connaissance du contexte local, qu'est-ce que vous suggérez le plus afin de commencer à développer localement de petits satellites?
a- de travailler avec des entreprises étrangères sur des technologies relativement anciennes, moins complexe, offrant des performances système relativement modestes ou faibles
b- de travailler avec des entreprises étrangères sur des technologies relativement nouvelles, complexe, offrant des performances système relativement élevées
c- de travailler **plus souvent** sur des technologies avec un risque d'échec plus élevé (non-achèvement de projet ou défaillance du système) plutôt que de travailler **moins souvent** sur des technologies avec un risque d'échec moindre

83) Est-ce que vous êtes confiant des aptitudes de votre organisation pour développer des petits satellites localement?

84) Comment qualifiez-vous la politique nationale en matière de Recherche, de Développement et d'Engineering et son impact sur la technologie des satellites? Comment qualifiez-vous l'intensité (ex. investissement, etc.) et les outputs (résultats, etc.) de ces activités? Sont-ils à orientés vers la Recherche fondamentale, recherche appliquée, ou vers les aspects les plus pratiques?

-Comment qualifiez-vous l'environnement national des sciences et technologies (politique des sciences et technologies, politiques de la R&D, réglementation, etc.) et son impact sur le développement des technologies des satellites? Comment qualifiez-vous l'intensité (ex. investissement, etc.) des activités dans cet environnement et leurs relations aux technologies satellitaires? Est-ce-que les actions promues dans cet environnement sont orientées vers la Recherche fondamentale, recherche appliquée, ou vers les aspects les plus pratiques?

-Comment qualifiez-vous l'environnement industriel national (politique industrielle, politique de l'industrie de haute technologie, politique d'innovation, réglementation, etc.) ? Comment qualifiez-vous l'intensité (ex. investissement, etc.) des activités dans cet environnement et leurs relations aux technologies satellitaires?

-Comment qualifiez-vous le contexte économique national et son impact sur le développement des technologies de satellites? Comment qualifiez-vous l'intensité (ex. systèmes de financement, etc.) des activités dans cet environnement et leurs relations aux technologies satellitaires?

-Comment qualifiez-vous l'évolution en termes de dépendance organisationnelle du secteur spatial au niveau national (d'une agence sous le Premier Ministère (ou Chefferie du Gouvernement), puis sous MPTIC (Ministère des Postes et de l'information et des communications Technologies), puis de nouveau sous Premier Ministère)? Dans quelle mesure ce changement a affecté le progrès de ce secteur?

85) Les objectifs socio-économiques font partie des objectifs du programme spatial en Algérie, est-ce-que l'inspiration de la nation, la fierté de la nation, redonner confiance au peuple font explicitement partie de ces objectifs?

Appendix 2-c: Questionnaires for representatives of local partners (English version)

Date:	Participant ID:

Questions on building small satellite capabilities in Algeria

addressed to representatives of entities involved in the process
(Doctoral School of Space Technology and Applications - EDTAS)

Research aim: To collect data in order to gain better understanding of satellite technology transfer to Algeria. This will enable Algerians to gain an appreciation on the effectiveness of the mechanisms that they have used to build satellite technological capabilities, and will provide guidance regarding effective processes to transfer satellite technology.

Guidance in responding to questions:

- The researcher will be interviewing you by himself in a face-to-face meeting to ensure proper understanding of questions and responses.
- Please feel free to use Arabic, French or English when responding.
- Feel free to include any oral or written comments, or material deemed relevant or supportive to your responses.
- All responses will be treated as confidential with only the researcher having access to them.

Sections covered:

A. General information
B. Learning effort
C. Capability-building management
D. Technology transfer management
E. Final suggestions

A. General information

1) What is your current position and describe your responsibilities and duties with regard to the Doctoral School of Space Technology and Applications - EDTAS? How long have you been EDTAS' coordinator?

2) Describe the EDTAS' missions in general and its operating mechanism?

3) What kind of relationships EDTAS has with ASAL?

4) One of the stated goals of the Algerian space programme is to progressively develop satellite capabilities. The successive collaborative projects with foreign partners (e.g. Alsat-1, Alsat-2A, Alsat-2B, Alsat-1B) have been used as a mechanism, how important is EDTAS contribution in the development of small satellite technology in Algeria? Does EDTAS have an explicit (written) policy and strategy with regard to small satellite development (or remote sensing small satellite development)?

5) How clear you find the objectives defined by ASAL when it comes to implementing them by EDTAS?

6) How flexible are these objectives in terms of: a) specification (freedom to adjust specifications or to completely review objectives); b) funding (freedom to ask more money); and c) time (freedom to go beyond the agreed timeline)?

7) How risky do you find these objectives?

8) How ambitious do you find these objectives?

9) In your view, what motivates people the most to join the EDTAS and particularly partake in developing satellite technology?

B. Learning effort

10) With regard to the training provided within the EDTAS, what were the shares for each area of specialisation (Space instrumentation, Space telecommunications and computing, Image processing and GIS, optics and precision mechanics, Space telecommunications, etc.) since the creation of the EDTAS? (e.g. number of master and PhD students)

11) How have these areas of specialisation (Space instrumentation, Space telecommunications and computing, Image processing and GIS, optics and precision mechanics, Space telecommunications, etc.) been defined? Were they defined according to ASAL's needs? Were they defined according to EDTAS available capabilities?

12) How are research projects in EDTAS identified or defined, conducted, funded, and managed? What is ASAL's role in these projects?

13) What are the disciplines you target as part of small satellite technology to be developed?

14) In your view, what were the main contributions of the successive satellite projects (Alsat-1, Alsat-2A, Alsat-2B, Alsat-1B) for EDTAS activities and vice-versa?

15) One of the goals of the Algerian space programme is to develop capabilities to integrate satellites. What would be the role of EDTAS in developing integrative knowledge (technology management, system engineering, etc.)

16) How do you find the student prior level when it comes to involving them in satellite R&D? How do you identify the needs? How are the students selected?

17) Are/were these students involved, during or after their EDTAS training, in ASAL's activities? Do you have any feedback on their skills with regard to work requirements or/and satellite development?

For developing technological capabilities, three activities are often jointly fostered: Research, Development and Engineering, wherein:
- "Research" refers to basic research
- "Development" refers to translating technical and scientific knowledge into products, processes, and services
- "Engineering" refers to very practical aspects

18) How do you find the nature of the EDTAS activities in terms of "Research" and "Development"? are they research-centred or development-centred? What would be the proportions of these activities in EDTAS?

19) What are the actions undertaken for translating these R&D activities into "Engineering" activities and vice-versa? How are the R&D activities commercialised? What are the achievements with regard to each activity? (e.g. patents, commercialised products, etc.)

20) Are these activities (i.e. Research, Development) conducted internally (within universities laboratories, etc.) or partly outsourced (conducted within industry environment)?

21) In your view and based on your knowledge of the Algerian university context, what would be the core-competences in satellite technology R&D to build locally and those to import?

22) In addition to its academic training mission, does EDTAS conduct "on-demand" research outside the academic setting? What are the mechanisms in place to carry out such research?

23) How would you describe interactions between EDTAS' researchers and ASAL's personnel (intense, formal, informal, framed, etc.)? (Joint project, joint research, joint publication, etc.). Indicate whether researchers who participated in satellite projects (Alsat-1, Alsat-2A, Alsat-2B, Alsat-1B) are involved in these exchanges?

24) How would you describe interactions between EDTAS' researchers themselves, and between various universities involved (intense, formal, informal, framed, etc.)? (Joint project, joint research, joint publication, etc.)

C. Capability-building management

25) How appropriate are the equipment and facilities of EDTAS for conducting R&D activities in satellite technology?

26) How appropriate are the human resources of EDTAS for conducting R&D activities in satellite technology? (Teams' sizes, teams' disciplines, team's motivations, teams' skills, etc.)

27) How appropriate are the current managerial and organisational capabilities of EDTAS with regard to its missions and objectives?

D. Technology transfer management

28) Did the EDTAS benefit from the collaboration with ASAL in order to train its human resources for acquiring new skills, to update its equipment and facilities, or to adapt its organisation for new requirements related to satellite development?

29) In your view, what is the strategy that ASAL should adopt to incentivise EDTAS to be effectively involved in ASAL's activities with regard to satellite development?

30) How would you describe the international collaboration of EDTAS with regard to R&D on satellite technology?

31) In technology intensive industries such as satellite industry, managing intellectual property issues (e.g. patents, etc.) is important. How are these issues managed within EDTAS?

E. Final suggestion

32) Do you have other market needs that can be met by using EDTAS's capabilities and the knowledge acquired (e.g. aeronautic, medical technologies, etc.)? Are you envisaging addressing these markets?

33) How confident do you feel about EDTAS's ability in order to support small satellites development locally?

34) How conducive do you find the national environment for EDTAS and the development of its activities?

Appendix 2-d: Questionnaires for representatives of local partners (French version)

Date:	Participant ID:

Questions sur la mise en place de capacités de développement de petits satellites en Algérie

adressées aux représentants des entités impliquées dans ce processus
(Ecole Doctorale des Technologies et Applications Spatiales – EDTAS)

Objectifs de la recherche: Recueillir des données qui permettent de mieux comprendre le processus de transfert des technologies satellitaires pour le cas de l'Algérie. Cela permettra aux Algériens d'avoir une appréciation sur l'efficacité des mécanismes qu'ils utilisent pour mettre en place un potentiel de développement des technologies de petits satellites, et fournira des indications sur les processus les plus efficaces à adopter pour transférer les technologies satellitaires.

Orientations pour répondre aux questions:

- Le chercheur lui-même vous interviewera (face-à-face) lors d'une réunion, à convenir, pour s'assurer de la bonne compréhension des questions et de la bonne formulation des réponses.
- Utilisez, à votre convenance, l'arabe, le français ou l'anglais au moment de répondre.
- Vous pouvez faire, à votre convenance, des commentaires, oraux ou écrits, et joindre tout document que vous estimeriez pertinent.
- Toutes les réponses seront traitées de manière confidentielle. Seul le chercheur aura accès à ces réponses.

Sections couvertes:

A. Informations générales
B. Effort d'apprentissage
C. Management du développement des capacités
D. Management du transfert des technologies
E. Suggestions finales

A. Informations générales

1) Quelle est votre poste/position actuel et décrivez vos responsabilités et fonctions par rapport à l'Ecole Doctorale des Technologies et Applications Spatiales? Combien de temps avez-vous passé en tant que Coordinateur de l'EDTAS ?

2) Décrivez les missions de l'EDTAS en général et son mécanisme de fonctionnement ?

3) Quel genre de relations l'EDTAS a avec l'ASAL ?

4) L'un des buts déclarés du programme spatial algérien est de développer progressivement des capacités satellitaires. Les projets collaboratifs successifs avec des partenaires étrangers (ex. Alsat-1, Alsat-2A, Alsat-2B, Alsat-1B) ont été utilisés comme mécanisme. expliquez l'importance de sa contribution dans le développement des technologies des petits satellites en Algérie? Est-ce que l'EDTAS a une politique/stratégie explicite (écrite) en matière de développement de petits satellites (ou le développement des petits satellites de télédétection)?

5) Comment trouvez-vous la clarté des objectifs définis par l'ASAL lorsqu'il s'agit de les mettre en œuvre en actions par l'EDTAS?

6) Comment qualifiez-vous la flexibilité de ces objectifs en termes de spécifications (liberté d'ajuster les spécifications ou revoir complètement les objectifs) ? en termes de financement (liberté de demander plus d'argent) ? en termes de délais (liberté d'aller au-delà des délais) ?

7) Comment qualifiez-vous le risque associé à ces objectifs?

8) Comment qualifiez-vous l'ambition de ces objectifs?

9) Selon vous, qu'est-ce qui motive le plus les gens à se joindre l'EDTAS et notamment participer au développement des technologies satellitaires ?

B. Effort d'apprentissage

10) S'agissant des formations dispensées au niveau de l'EDTAS, quels sont les parts de formations par spécialité (instrumentation spatiale, télécommunication et informatique spatiales, traitement d'images et SIG, Optique et mécanique de précision, télécommunications spatiales, etc.) et ce depuis la création de l'EDTAS ? (number of student in masters, doctorat)

11) Comment ces domaines de spécialisation (instrumentation spatiale, télécommunication et informatique spatiales, traitement d'images et SIG, Optique et mécanique de précision, télécommunications spatiales, etc.) ont été définis? Ont-ils été définis en fonction des besoins de l'ASAL? Ont-ils été définis en fonction des capacités disponibles de l'EDTAS?

12) Comment les projets de recherche dans l'EDTAS sont identifiés et définis, menées, financés, et gérées? Quel est le rôle de l'ASAL dans ces projets ?

13) Quelles sont les disciplines que vous ciblez dans les technologies des petits satellites à développer?

14) Selon vous, quelles ont été les principales contributions des projets successifs de satellites (Alsat-1, Alsat-2A, Alsat-2B, Alsat-1B) aux activités de l'EDTAS and vice-versa?

15) L'un des objectifs du programme spatial algérien est de développer les capacités d'intégration des satellites. Quel serait le rôle de l'EDTAS dans le développement des connaissances intégratives (Management de la technologie, l'ingénierie des systèmes, etc.)

16) Comment trouvez-vous le niveau initial des étudiants impliqués dans la R&D satellitaire? Comment identifiez-vous les besoins? Comment les étudiants sont sélectionnés?

17) Est-ce que ces étudiants ont été impliqués, au cours ou à l'issue de leur formation à l'EDTAS, aux activités de l'ASAL ? Est-ce que vous avec eu un feedback sur leurs compétences par rapport aux exigences d'emploi ou/et de développement de satellites?

Pour développer des capacités technologiques, trois activités sont souvent conjointement encouragées: la « Recherche », le « Développement » et « l'Ingénierie ou Engineering », où:

- "Recherche" fait référence à la recherche fondamentale
- "Développement" fait référence à la traduction de connaissances techniques et scientifiques en produits, procédés et services
- " Ingénierie ou Engineering" fait référence à des aspects très pratiques

18) Comment trouvez-vous la nature des activités de l'EDTAS en termes de «recherche» et «développement», sont-elles centrées sur la recherche ou sur le développement? Quelles seraient les proportions de ces activités dans l'EDTAS?

19) Quelles sont les actions entreprises pour traduire ces activités de R&D en activités d' «Engineering» et vice-versa? Comment ces activités de R&D sont valorisées (et commercialisées) ? Quelles sont les réalisations pour ces activités? (ex. Brevets, produits commercialisables, etc.)

20) Est-ce ces activités (« Recherche », « Développement ») sont menées en interne (dans des laboratoires d'universités) ou en partie externalisées (menées dans un environnement industriel)?

21) Selon vous et sur la base de votre connaissance du contexte universitaire algérien, quelles seraient les compétences clés à développer localement en matière de R&D en technologies satellitaires et celles à importer ?

22) En plus de sa mission de formation académique, est-ce que l'EDTAS peut effectuer des recherches à la demande et en dehors du cadre académique ? Quel sont les mécanismes mis en place pour mener de telles recherches ?

23) Comment qualifiez-vous les interactions et échanges entre les chercheurs de l'EDTAS et le personnel de l'ASAL (intense, formel, informel, encadré, etc.) ? (projets conjoints, recherches conjointes, publications conjointes, etc.). indiquez si des chercheurs qui ont participé aux projets satellitaires (Alsat-1, Alsat-2A, Alsat-2B, Alsat-1B) sont impliqués dans ces échanges.

24) Comment qualifiez-vous les interactions et échanges entre les chercheurs de l'EDTAS, entre eux, et entre les différentes universités impliquées (intense, formel, informel, encadré, etc.) ? (projets conjoints, recherches conjointes, publications conjointes, etc.)

C. Management du développement des capacités

25) Est-ce que les équipements et installations de l'EDTAS sont appropriés pour la conduite d'activités de R&D dans les technologies satellitaires ?

26) Est-ce que les ressources humaines de l'EDTAS sont appropriées pour la conduite d'activités de R&D dans les technologies satellitaires ? (Tailles des équipes, disciplines des équipes, motivations des équipes, compétences des équipes, etc.)

27) Est-ce que les capacités managériales et organisationnelles actuelles de l'EDTAS sont appropriées à ses missions et objectifs ?

D. Management du transfert des technologies

28) Est-ce que l'EDTAS a bénéficié de la collaboration avec l'ASAL pour former ses ressources humaines et acquérir de nouvelles compétences, pour mettre à jour ses équipements et installations, ou adapter son organisation aux nouveaux besoins liés au développement de satellites?

29) Selon vous, quelle est la stratégie que devrait adopter l'ASAL pour inciter l'EDTAS à participer efficacement aux activités de l'ASAL en matière de développement de satellites?

30) Comment qualifiez-vous la collaboration internationale de l'EDTAS en matière de R&D portant sur la technologie satellitaire ?

31) Dans les industries à forte intensité technologique telles que l'industrie satellitaire, la gestion des questions de propriété intellectuelle (ex. les brevets, etc.) est importante. Comment ces questions sont gérées dans l'EDTAS?

E. Suggestions finales

32) Avez-vous d'autres marchés dont les besoins peuvent être satisfaits en utilisant les capacités qui sont en cours de développement et les connaissances qui ont été acquises? Est-ce que vous envisagez de vous adresser à ces marchés?

33) Est-ce que vous êtes confiant des aptitudes de l'EDTAS pour apporter le support au développement de petits satellites localement?

34) Dans quelle mesure trouvez-vous l'environnement national favorable pour le travail de l'EDTAS et le développement de ses activités?

Appendix 2-e: Questionnaires for representatives of local partners (English version)

Date:	Participant ID:

Questions on building small satellite capabilities in Algeria

addressed to representatives of entities involved in the process
(Aircraft construction company - ECA)

Research aim: To collect data in order to gain better understanding of satellite technology transfer to Algeria. This will enable Algerians to gain an appreciation on the effectiveness of the mechanisms that they have used to build satellite technological capabilities, and will provide guidance regarding effective processes to transfer satellite technology.

Guidance in responding to questions:

- The researcher will be interviewing you by himself in a face-to-face meeting to ensure proper understanding of questions and responses.
- Please feel free to use Arabic, French or English when responding.
- Feel free to include any oral or written comments, or material deemed relevant or supportive to your responses.
- All responses will be treated as confidential with only the researcher having access to them.

Sections covered:

A. General information
B. Learning effort
C. Capability-building management
D. Technology transfer management
E. Final suggestions

A. General information

1) What is your current position and describe your responsibilities and duties within your organisation? How long have you been in this position? How long have you been in this organisation?

2) Describe your organisation missions in general and explain how important is your participation in the development of small satellite technology in accomplishing these missions (economic importance, technological importance, company's image, etc.)? Does your organisation have a policy and strategy with regard to the participation in small satellite development?

3) One of the stated goals of the Algerian space programme is to develop locally and progressively satellite capabilities, how clear do you find this objective with regard to your organisation involvement?

4) How risky do you find your involvement in this objective considering your own capabilities?

5) How ambitious do you find your involvement in this objective considering your own capabilities?

6) In your view, what motivates organisations/firms the most to join the Algerian Space Agency -ASAL and partake in developing satellite technology?

B. Learning effort

7) What did your organisation develop as part of satellite projects? Describe your successive participations.

8) In your view, what was the learning benefit for each of your participation in satellite projects? Have you improved your capabilities of: Design and specification, Project management, Systems engineering, System integration, manufacturing and machining?

9) How are the participation experiences and lessons learnt stored (e.g. routines, tests, procedures)? How is documentation and knowledge acquired throughout collaboration with ASAL or produced internally managed (gathered, recorded, stored in DB, diffused locally, updated, computer-aided information system etc.)? Describe the strategy adopted and the mechanisms that have been put in place?

10) To what extent are individuals involved in these projects kept working on similar tasks and activities in Algeria? Describe whether mechanisms are put in place to ensure that this happens? (How do you manage the loss of qualified or experienced personnel due for instance to long interruptions in the work process, brain drain, etc.?)

11) What are the mechanisms used to ensure that individuals involved in these projects mentor/supervise new individuals and share their knowledge?

12) During your participation in these projects, what were the disciplines in which your organisation was involved? Precise whether these disciplines are usually covered by your organisation or they were developed for the purpose of this collaboration?

13) After these experiences, what are the disciplines that you target in order to enlarge and deepen your participation in satellite projects? Precise whether you are going to develop these disciplines internally or to outsource them?

14) As part of your usual activities, what are the activities that are carried out internally and those outsourced?

15) How do you find the prior knowledge of your personnel with regard to their involvement in satellite development? In your view, how close is their knowledge to that required for developing satellites locally?

16) What is the impact of partaking in these projects on the skills of the personnel involved?

For developing technological capabilities, three activities are often jointly fostered: Research, Development and Engineering, wherein:

- "Research" refers to basic research
- "Development" refers to translating technical and scientific knowledge into products, processes, and services
- "Engineering" refers to very practical aspects

17) How important is each of these activities (i.e. Research, Development, and Engineering) for your organisation objectives? And what about human resources available in your organisation for each of these activities?

18) Are these activities (i.e. Research, Development, and Engineering) conducted internally or outsourced (developed outside the organisation)? What kinds of activities are conducted internally and what kinds are outsourced?

19) What are the objectives in terms of core-competencies to develop internally and elements to outsource (locally in Algeria)? In your view, what would be the core competencies and functions to develop and that would be required by satellite industry?

20) How would you describe interactions between your personnel and ASAL's personnel throughout the projects (intense, formal, informal, framed, etc.)?

C. Capability-building management

21) Based on your experience and exchange with ASAL's personnel and their partners, how appropriate are your equipment and facilities for satellite development requirements?

22) Estimate the proportions of the workforce involved in satellite technology development with ASAL for the following categories: Management, Operations, R&D, and Engineering?

D. Technology transfer management

23) Did your organisation benefit from the collaboration with ASAL in order to train its personnel for acquiring new skills, to update its equipment and facilities, or to adapt its organisation for new requirements related to satellite development?

24) In your view, what is the strategy that ASAL should adopt to incentivise your organisation to be more involved and to transfer effectively to your organisation the technology required for satellite development?

25) What kind of relationship do you usually have with ASAL after the projects? Are these relations maintained through formal agreements, are they intense, etc.? How do they evolve?

E. Final suggestion

26) Do you have other market needs that can be met by using the capabilities that have been built and knowledge acquired during ASAL's collaboration experience? Are you envisaging addressing these markets?

27) How confident do you feel about your organisation's ability in order to support small satellite development locally?

28) How conducive do you find the national environment for your organisation and the development of its activities?

Appendix 2-f: Questionnaires for representatives of local partners (French version)

Date:	Participant ID:

Questions sur la mise en place de capacités de développement de petits satellites en Algérie

adressées aux représentants des entités impliquées dans ce processus (Entreprise de Construction Aéronautique - ECA)

Objectifs de la recherche: Recueillir des données qui permettent de mieux comprendre le processus de transfert des technologies satellitaires pour le cas de l'Algérie. Cela permettra aux Algériens d'avoir une appréciation sur l'efficacité des mécanismes qu'ils utilisent pour mettre en place un potentiel de développement des technologies de petits satellites, et fournira des indications sur les processus les plus efficaces à adopter pour transférer les technologies satellitaires.

Orientations pour répondre aux questions:

- Le chercheur lui-même vous interviewera (face-à-face) lors d'une réunion, à convenir, pour s'assurer de la bonne compréhension des questions et de la bonne formulation des réponses.
- Utilisez, à votre convenance, l'arabe, le français ou l'anglais au moment de répondre.
- Vous pouvez faire, à votre convenance, des commentaires, oraux ou écrits, et joindre tout document que vous estimeriez pertinent.
- Toutes les réponses seront traitées de manière confidentielle. Seul le chercheur aura accès à ces réponses.

Sections couvertes:

A. Informations générales
B. Effort d'apprentissage
C. Management du développement des capacités
D. Management du transfert des technologies
E. Suggestions finales

A. Informations générales

1) Quelle est votre poste/position actuel ? et décrivez vos responsabilités et fonctions au sein de votre organisation? Combien de temps avez-vous passé dans ce poste/position? Combien de temps avez-vous passé dans cette organisation?

2) Décrivez les missions de votre organisation en général et expliquez l'importance de votre participation dans le développement des technologies des petits satellites? (importance économique, importance technologique, l'image de l'entreprise, etc.) Est-ce que votre organisation a une politique/stratégie en matière de participation dans le développement de petits satellites?

3) L'un des buts déclarés du programme spatial algérien est de développer localement et progressivement des capacités satellitaires, comment trouvez-vous cet objectif en termes de clarté lorsqu'il s'agit de l'implication de votre organisation?

4) Comment qualifiez-vous le risque associé à votre implication en tenant compte de vos capacités ?

5) Comment qualifiez-vous l'ambition associée à votre implication en tenant compte de vos capacités ?

6) Selon vous, qu'est-ce qui motive le plus les organisations/firmes à se joindre à l'Agence Spatiale Algérienne -ASAL et à participer au développement des technologies satellitaires ?

B. Effort d'apprentissage

7) Qu'est-ce-que votre organisation a fait dans les projets satellitaires? Décrirez vos participations successives.

8) Selon vous, en quoi cette participation a été bénéfique à votre entreprise en termes d'apprentissage ? avez-vous amélioré vos capacités de : Conception et les spécifications, gestion de projet, ingénierie des systèmes, intégration du système, fabrication et l'usinage?

9) Comment les expériences et leçons apprises durant cette participation sont sauvegardées (ex. routines de tests, procédures)? Comment la documentation et les connaissances acquises tout au long de la participation collaboratifs, ou celles produites en interne sont gérées (recueillies, enregistrées, stockées dans des bases de données, diffusées localement, mises à jour, système d'information assistée par ordinateur, etc.)? Décrivez la stratégie adoptée et les mécanismes mis en place?

10) Dans quelle mesure les individus impliqués dans des projets collaboratifs sont tenus de travailler sur des activités et des tâches similaires? Décrivez si des mécanismes sont mis en place? (Comment gérez-vous la perte de personnel qualifié ou expérimenté en raison, par exemple, de longues périodes d'interruptions dans le processus de travail, sortir de l'organisation, etc.?)

11) Quels sont les mécanismes utilisés pour assurer que les personnes impliquées dans ses projets supervisent (ou assurent du mentoring) de nouveaux individus et partagent leurs connaissances?

12) Durant votre participation dans ces projets, quelles ont été les disciplines impliquées au sein de votre organisation ? précisez si ces disciplines sont habituellement couvertes au sein dans votre organisation, ou elles ont été développées pour les besoins de cette collaboration?

13) Après ces expériences, quelles sont les disciplines que vous ciblez dans le but d'élargir et d'approfondir votre participation à des projets de satellites? Précisez si vous allez développer ces disciplines en interne ou vous allez les sous-traiter?

14) Dans le cadre de vos activités habituelles, quelles sont les activités qui sont faites en interne et celles sous-traités?

15) Comment trouvez-vous les connaissances préalables de votre personnel quant à leur implication dans le développement de satellite? Selon vous, comment trouvez-vous leurs compétences par rapport aux exigences de développement de satellites localement?

16) Quel est l'impact de la participation dans ces projets sur les compétences du personnel impliqué?

Pour développer des capacités technologiques, trois activités sont souvent conjointement encouragées: la « Recherche », le « Développement » et « l'Ingénierie ou Engineering », où:

- "Recherche" fait référence à la recherche fondamentale
- "Développement" fait référence à la traduction de connaissances techniques et scientifiques en produits, procédés et services
- " Ingénierie ou Engineering" fait référence à des aspects très pratiques

17) Quelle est l'importance de chacune de ces activités (« Recherche », « Développement », et « Engineering ») pour les objectifs de votre organisation? Et qu'en est-il des ressources humaines disponibles dans votre organisation pour chacune de ces activités?

18) Est-ce ces activités (« Recherche », « Développement », et « Engineering ») sont menées en interne ou externaliser (développé en dehors de l'organisation)? Quels types d'activités sont effectués en interne et quels types sont externalisés?

19) Quels sont les objectifs en termes de compétences clés (core-competencies) à développer en interne et les éléments à externaliser (localement en Algérie)? Selon vous, quelles seraient les compétences clés et les fonctions de base à développer et qui pourraient être requises par l'industrie des satellites ?

20) Comment qualifiez-vous les interactions et échanges entre votre personnel et le personnel de l'ASAL durant ce projet (intense, formel, informel, encadré, etc.) ?

C. Management du développement des capacités

21) Sur la base de votre expérience ainsi que les échanges avec le personnel de l'ASAL et de ses partenaires, Est-ce que vos équipements et installations sont appropriés aux spécifications requises pour le développement de satellites?

22) Estimez la proportion de la main-d'œuvre impliquée dans des taches de développement de satellites avec l'ASAL, pour les catégories suivantes : Management, Opérations, R & D et Engineering.

D. Management du transfert des technologies

23) Est-ce que votre organisation a bénéficié de la collaboration avec l'ASAL pour former son personnel et acquérir de nouvelles compétences, pour mettre à jour ses équipements et installations, ou adapter son organisation aux nouveaux besoins liés au développement de satellites?

24) Selon vous, quelle est la stratégie que devrait adopter l'ASAL pour inciter votre organisation à participer davantage et de transférer efficacement à votre organisation la technologie requise pour le développement de satellites?

25) Quel genre de relations avez-vous généralement avec l'ASAL après le projet? Est-ce que ces relations sont entretenues par des accords formels, sont-elles intenses, etc.? Comment évoluent-elles?

E. Suggestions finales

26) Avez-vous d'autres marchés dont les besoins peuvent être satisfaits en utilisant les capacités qui ont été développées et les connaissances qui ont été acquises au cours de l'expérience de collaboration avec l'ASAL? Est-ce que vous envisagez de vous adresser à ces marchés?

27) Est-ce que vous êtes confiant des aptitudes de votre organisation pour apporter le support au développement de petits satellites localement?

28) Dans quelle mesure trouvez-vous l'environnement national favorable pour le travail de votre organisation et le développement de ses activités?

Appendix 2-g: Questionnaires for representatives of foreign suppliers (English version)

Date:	Participant ID:

Questions on building small satellite capabilities in Algeria

addressed to representatives of foreign companies involved in the process

Research aim: Collection of data in order to gain better understanding of satellite technology transfer to Algeria. This will enable Algerians to gain an appreciation on the effectiveness of the mechanisms that they have used to build satellite technological capabilities, and will provide guidance regarding effective processes for transferring satellite technology.

Guidance in responding to questions:

- The researcher will be interviewing you by himself in a face-to-face meeting to ensure proper understanding of questions and responses.
- Please feel free to use French or English when responding.
- Feel free to include any oral or written comments, or material deemed relevant or supportive to your responses.
- All responses will be treated as confidential with only the researcher having access to them.

1) What is your current position and describe your responsibilities and duties within your organisation?

2) Describe your responsibilities with regard to the satellite collaborative project with ASAL?

3) In your view, how close do you find the prior knowledge of ASAL's engineers to the requirements for partaking in the collaborative project? How did you find their selection process?

4) What are the mechanisms used for the evaluation of learning which occurred during the project (e.g. metrics used, milestones, targets)? Was your view of learning shared with that of the Algerian part? (i.e. the same understanding of the boundaries and the targets/goals of learning)

5) Work packages were used in order to define tasks and activities to be performed by ASAL's engineers during the project. According to some of them, these work packages were sometimes not understood, very general and not enough detailed, or too narrowly oriented towards much specialised aspects, or not properly balanced (fostering either theoretical or practical aspects), or disregarding the prior knowledge of ASAL's engineers, or even depending upon the mentor's willingness or availability? In your view, how properly were the work packages formulated in accordance with ASAL's needs?

6) Interviews conducted with some ASAL's engineers who participated in the collaborative project with your company reveal a dissatisfaction with regard to the documentation provided at the end of the project (e.g. not complete, not deep, etc.). In your view, what would be the reason of this dissatisfaction?

7) According to ASAL's representatives, one of the weakest aspects in the collaborative project with your company is the training (and skills development) on management of satellite projects. In your view, what would be the reason of this?

8) ASAL's engineers acquired academic and hands-on knowledge during the collaborative project with your company. According to them, little was acquired on satellite design. What would be the reason of this limitation (e.g. due to restrictions from your company, aspect not offered in the business model of your company, aspect not covered by the contract, etc.)?

9) According to ASAL's engineers, factors such as the working language(s) and idiosyncratic personality of engineers (from both sides) involved in the project have influenced significantly the mutual understanding between ASAL's team and your team. To what extent do you agree with this statement?

10) In your view, after the participation of ASAL's engineers in the project, how close is their knowledge to the requirements of developing satellite locally in Algeria?

11) In your view, what has been the priority of ASAL during the project: the acquisition of satellite system and its deployment for meeting its needs in terms of satellite images and applications, or learning how to develop satellites (completely or partially)? What is the aspect most fostered by the mechanism used for carrying out the project?

12) In your view, for starting developing small satellites within ASAL's facilities, what would be the core competencies and functions to develop?

13) Based on your experience during the project, to what extent the formal project contract (between your company and ASAL) was representative of the real needs of ASAL? What would be the strategy to adopt in the future to avoid inadequacies between contracts and real needs?

14) Based on your experience, how risk-averse do you find ASAL during the project?

15) What kind of relationship do you usually have with your customers after the projects? Are these relations maintained through formal agreements, are they intense, etc.? How do they evolve?

16) ASAL intends to build local capabilities for developing small satellites. For this purpose, ASAL should acquire from abroad a significant number of physical components and equipment. If some components and equipment are subject to restrictive regimes, how would you describe the openness of the international market for offering alternative options?

Appendix 2-h: Questionnaires for representatives of foreign suppliers (French version)

Date:	Participant ID:

Questions sur la mise en place de capacités de développement de petits satellites en Algérie

adressées aux représentants des entités impliquées dans ce processus

Objectifs de la recherche: Recueillir des données qui permettent de mieux comprendre le processus de transfert des technologies satellitaires pour le cas de l'Algérie. Cela permettra aux Algériens d'avoir une appréciation sur l'efficacité des mécanismes qu'ils utilisent pour mettre en place un potentiel de développement des technologies de petits satellites, et fournira des indications sur les processus les plus efficaces à adopter pour transférer les technologies satellitaires.

Orientations pour répondre aux questions:

- Le chercheur lui-même vous interviewera (face-à-face) lors d'une réunion, à convenir, pour s'assurer de la bonne compréhension des questions et de la bonne formulation des réponses.
- Utilisez, à votre convenance, le français ou l'anglais au moment de répondre.
- Vous pouvez faire, à votre convenance, des commentaires, oraux ou écrits, et joindre tout document que vous estimeriez pertinent.
- Toutes les réponses seront traitées de manière confidentielle. Seul le chercheur aura accès à ces réponses.

1) Quelle est votre poste/position actuel et décrivez vos responsabilités et fonctions au sein de votre organisation?

2) Décrivez vos responsabilités par rapport au projet collaboratif de satellite avec l'ASAL?

3) Selon vous, comment trouvez-vous les connaissances préliminaires/antérieures des ingénieurs de l'ASAL par rapport aux exigences de participation dans le projet collaboratif ? Comment avez-vous trouvé the processus de leur sélection ?

4) Quels sont les mécanismes utilisés pour l'évaluation de l'apprentissage survenant au cours du projet (ex. métriques utilisés, jalons, cibles) ? Est-ce que votre vision de l'apprentissage était partagée avec celle de la partie algérienne ? (C.-à-d. la même compréhension des limites et des cibles/buts de l'apprentissage)

5) Des « Work packages » ont été utilisés pour définir les tâches et les activités à réaliser par les ingénieurs de l'ASAL pendant le projet. Selon certains de ces ingénieurs, les « Work packages » étaient parfois mal compris, très généraux et peu détaillés, ou trop étroitement orientés vers des aspects très spécialisés, ou mal équilibrés (favorisant ou bien des aspects théoriques ou pratiques) ou négligeant les connaissances antérieures des ingénieurs de l'ASAL, ou même dépendant de la volonté ou de la disponibilité du mentor ? Selon vous, dans quelle mesure les « Work packages » ont été formulés en conformité avec les besoins de l'ASAL ?

6) Les interviews menées avec certains ingénieurs de l'ASAL qui ont participé au projet de collaboration avec votre compagnie révèlent une insatisfaction par rapport à la documentation fournie à la fin du projet (ex. incomplète, non profonde, etc.). Selon vous, quelle serait la raison de cette insatisfaction ?

7) Selon les représentants de l'ASAL, l'un des aspects les plus faibles du projet collaboratif avec votre compagnie est la formation (et le développement des compétences) dans le management des projets satellitaires. Selon vous, quelle serait la raison de cela ?

8) Les ingénieurs de l'ASAL ont acquis des connaissances académiques et pratiques au cours du projet collaboratif avec votre compagnie. Selon eux, peu a été acquis sur la conception de satellites. Quelle serait la raison de cette limitation (ex. restrictions de votre compagnie, aspects non offerts dans le modèle d'affaire 'Business model' de votre compagnie, aspects non couverts par le contrat, etc.)?

9) Selon les ingénieurs de l'ASAL, des facteurs tels que la(les) langue(s) de travail et la personnalité particulière des ingénieurs (des deux côtés) impliqués dans le projet ont influencé de manière significative la compréhension mutuelle entre l'équipe algérienne et votre équipe. Dans quelle mesure vous êtes d'accord avec cet avis ?

10) Selon vous, après la participation des ingénieurs de l'ASAL dans le projet, comment trouvez-vous leurs compétences par rapport aux exigences de développement de satellites localement en Algérie ?

11) Selon vous, quelle a été la priorité de l'ASAL durant le projet : l'acquisition d'un système satellitaire et son déploiement pour répondre à ses besoins en termes d'images satellitaires et d'applications, ou apprendre à développer des satellites (totalement ou partiellement) ? Quel est l'aspect le plus favorisé par le mécanisme utilisé pour la réalisation du projet ?

12) Selon vous, pour commencer le développement de petits satellites en niveau de l'ASAL, quelles seraient les compétences et les fonctions de base à développer ?

13) Sur la base de votre expérience durant le projet, dans quelle mesure le contrat formel du projet (entre votre compagnie et l'ASAL) était représentatif des besoins réels de l'ASAL ? Quelle serait la stratégie à adopter dans le futur pour éviter les inadéquations entre les contrats et les besoins réels ?

14) Sur la base de votre expérience, comment qualifiez-vous l'aversion au risque de l'ASAL ?

15) Quel genre de relations avez-vous généralement avec vos clients après les projets ? Est-ce que ces relations sont entretenues par des accords formels, sont-elles intenses, etc. ? Comment évoluent-elles ?

16) L'ASAL entend construire des capacités locales pour le développement de petits satellites. A cet effet, l'ASAL devrait acquérir de l'étranger un nombre important de composants physiques et d'équipements. Si certains composants et équipements sont soumis à des régimes restrictifs, comment qualifiez-vous l'ouverture du marché international pour offrir d'autres alternatives ?

Appendix 2-i: Questionnaires for ASAL top management (English version)

Date:	Participant ID:

Questions on building small satellite capabilities in Algeria

addressed to representatives of entities involved in the process

Research aim: Collection of data in order to gain better understanding of satellite technology transfer to Algeria. This will enable Algerians to gain an appreciation on the effectiveness of the mechanisms that they have used to build satellite technological capabilities, and will provide guidance regarding effective processes for transferring satellite technology.

Guidance in responding to questions:

- The researcher will be interviewing you by himself in a face-to-face meeting to ensure proper understanding of questions and responses.
- Please feel free to use Arabic, French or English when responding.
- Feel free to include any oral or written comments, or material deemed relevant or supportive to your responses.
- All responses will be treated as confidential with only the researcher having access to them.

Sections covered:

A. General information
B. Learning effort
C. Technology transfer management
D. Final suggestions

A. General information

1) The socio-economic objectives are part of the space programme objectives in Algeria, are nation inspiration, nation pride and confidence building amongst people explicitly part of these objectives?

2) One of the stated goals of the Algerian space programme is to progressively develop small satellite capabilities. The successive collaborative projects with foreign partners (e.g. Alsat-1, Alsat-2A, Alsat-2B, Alsat-1B) have been used as a mechanism, what are the targeted progressive phases?

B. Learning effort

3) As part of your strategy of small satellite technology development, indicate whether the objective is to develop components of satellite systems; develop capabilities to integrate small satellites from components developed elsewhere, or a mixture of the two? If the mixture is targeted, which core competencies and functions could be developed within your organisation, which could be developed locally in Algeria but outside your organisation, and which could be imported from foreign firms?

4) What are the strategies towards the development of local actors (public and private actors)? What are the actions taken for this purpose (e.g. identifying them, surveying them, training them, transferring technology to them, helping them upgrading their facilities, incentives, etc.)?

For developing technological capabilities, three activities are often jointly fostered: Research, Development and Engineering, wherein:

- "Research" refers to basic research
- "Development" refers to translating technical and scientific knowledge into products, processes, and services
- "Engineering" refers to very practical aspects

5) How would you describe the national policies in terms of Research, Development and Engineering promotion and their impacts on satellite technology? How would you describe the intensity (e.g. investment, etc.) and outputs of actions stemming from these policies? Are they towards basic research, applied aspects, or more practical aspects (engineering)?

6) What is the strategy and what are the actions undertaken for developing "Research", "Development", and "Engineering" activities in your organisation, notably those related to the needs of small satellite development? How important is each of these activities (i.e. Research, Development, and Engineering) for your organisation objectives? What are the actors in charge of Research promotion, Development promotion, and Engineering development with regard to satellite technology?

7) What is the strategy towards developing indigenous Engineering sector able to provide skills needed for satellite development and/or integration?

8) How would you describe the national labour market with regard to the development of satellite technology? Do you envisage recruiting from the international market (Algerian abroad or foreigners)?

C. Technology transfer management

9) Collaborative projects are a mechanism that has been used for the last 15 years by your organisation to develop satellite technological capability? In your view, how is this mechanism evaluated, what are its strengths and weaknesses, and to what extent has it met Algerian needs and complied with Algerian objectives? Considering the level reached of local capabilities and limitations of collaborative projects mechanism to go further, does ASAL envisage adopting new mechanisms (e.g. Licence production, relocation of foreign company activities, use of FDI-Foreign Direct Investment, etc.) for achieving higher levels of capabilities?

10) As technology transfer from abroad is an important way for developing satellite technology in Algeria, and in either technology transfer relationships or technology intensive industries, managing intellectual property issues (e.g. patents, etc.) is important for protecting foreign partners' intellectual property and local innovation effort. How are these issues managed in your organisation?

11) Sometimes, diversifying partners at international level can increase opportunities for technology transfer and overcome certain setbacks. To what extent does this apply to small satellite development in Algeria?

D. Final suggestion

12) How would you describe the needs of both local and international markets in terms of small satellite technology (components and systems market)? How would you describe the trend of small satellite markets (whether it evolves to suppliers markets, buyers markets, etc.)?

13) In your view, do you have other market technological needs that can be met by using the satellite capabilities under development and the knowledge acquired? (e.g. aeronautic, medical technologies, etc.) Are you envisaging addressing these markets?

14) How would you describe the local effort to develop small satellite? Is there more emphasis on the market development (users of satellite images, etc.) or satellite system development?

15) In your view, what is (would be) the guidance for Algerian efforts in developing small satellites: to develop (components and systems) for import substitution, or to develop for export to international market?

Appendix 2-j: Questionnaires for ASAL top management (French version)

Date:	Participant ID:

Questions sur la mise en place de capacités de développement de petits satellites en Algérie

adressées aux représentants des entités impliquées dans ce processus

Objectifs de la recherche: Recueillir des données qui permettent de mieux comprendre le processus de transfert des technologies satellitaires pour le cas de l'Algérie. Cela permettra aux Algériens d'avoir une appréciation sur l'efficacité des mécanismes qu'ils utilisent pour mettre en place un potentiel de développement des technologies de petits satellites, et fournira des indications sur les processus les plus efficaces à adopter pour transférer les technologies satellitaires.

Orientations pour répondre aux questions:

- Le chercheur lui-même vous interviewera (face-à-face) lors d'une réunion, à convenir, pour s'assurer de la bonne compréhension des questions et de la bonne formulation des réponses.
- Utilisez, à votre convenance, l'arabe, le français ou l'anglais au moment de répondre.
- Vous pouvez faire, à votre convenance, des commentaires, oraux ou écrits, et joindre tout document que vous estimeriez pertinent.
- Toutes les réponses seront traitées de manière confidentielle. Seul le chercheur aura accès à ces réponses.

Sections couvertes:

A. Informations générales
B. Effort d'apprentissage
C. Management du transfert des technologies
D. Suggestions finales

A. Informations générales

1) Les objectifs socio-économiques font partie des objectifs du programme spatial en Algérie, est-ce-que l'inspiration de la nation, la fierté de la nation, redonner confiance au peuple font explicitement partie de ces objectifs?

2) L'un des buts déclarés du programme spatial algérien est de développer en phase et progressivement des capacités de développement de petits satellites. Les projets collaboratifs successifs avec des partenaires étrangers (ex. Alsat-1, Alsat-2A, Alsat-2B, Alsat-1B) ont été utilisés comme mécanisme. Quelles sont ces phases progressives ciblées ?

B. Effort d'apprentissage

3) Dans votre stratégie de développement de technologies de petits satellites, Est-ce que les objectifs sont de développer des composants de systèmes de satellites; développer des capacités à intégrer de petits satellites à partir de composants développés ailleurs, ou un mélange? Si le mélange est ciblé, quelles seraient les compétences clés et les fonctions de base à développer au sein de votre organisation, celles à développer localement en Algérie, mais en dehors de votre organisation, et celles à importer de l'étranger?

4) Quelles sont les stratégies en faveur du développement des acteurs locaux, gouvernementaux ou privés? Quelles sont les mesures prises à cet effet (ex. identifier les acteurs, les auditer, les former, transférer la technologie pour eux, les aider à mettre à niveau leurs installations, les mesures incitatives, etc.)?

Pour développer des capacités technologiques, trois activités sont souvent conjointement encouragées: la « Recherche », le « Développement » et « l'Ingénierie ou Engineering », où:

- "Recherche" fait référence à la recherche fondamentale
- "Développement" fait référence à la traduction de connaissances techniques et scientifiques en produits, procédés et services
- " Ingénierie ou Engineering" fait référence à des aspects très pratiques

5) Comment qualifiez-vous les politiques nationales en matière de Recherche, de Développement et d'Engineering et leurs impacts sur la technologie des satellites? Comment qualifiez-vous l'intensité (ex. investissement, etc.) des actions qui en découlent et leurs résultats? Sont-elles orientées vers la Recherche fondamentale, recherche appliquée, ou vers les aspects les plus pratiques?

6) Quelles sont les actions entreprises pour développer les activités de « Recherche », « développement », et « Engineering » dans votre organisation notamment en relations avec les besoins de développement de petits satellites? quelle est l'importance de chacune de ces activités (« Recherche », « Développement », et « Engineering ») pour les objectifs de votre organisation? Quels sont les acteurs en charge de la promotion de la Recherche, du Développement, et de l'Engineering en matière de technologie des satellites?

7) Quelle est la stratégie pour le développement d'un secteur local de l'Engineering en mesure de fournir les compétences nécessaires pour le développement et / ou l'intégration des satellites?

8) Comment qualifiez-vous la marché national du travail par rapport au développement des technologies satellitaires? Envisagez-vous le recrutement du marché international (Algériens à l'étranger ou étrangers)?

C. Management du transfert des technologies

9) Les projets collaboratifs ont été utilisés comme mécanisme de développement de capacités technologiques satellitaires les 15 dernières années par votre organisation, comment évaluez-vous ce mécanisme, quelles sont ses points forts et ses points faibles, et dans quelle mesure il a répondu aux besoins et objectifs algériens? Considérant le niveau atteint des capacités locales et des limitations des projets collaboratifs de satellites comme mécanisme pour aller plus loin dans le transfert, est-ce que

l'ASAL envisage l'adoption de nouveaux mécanismes (ex. Licence de production, délocalisation des activités d'entreprises étrangères, Utilisation d'investissements directs étrangers IDE, etc.) pour des niveaux de réalisations plus élevés?

10) Compte tenu du fait que le transfert de technologies de l'étranger est crucial pour le développement de technologies satellitaire, et compte tenu du fait que dans les relations de transferts de technologies et les industries à forte intensité technologique, la gestion des questions de propriété intellectuelle (ex. les brevets, etc.) est importante pour protéger la propriété intellectuelle des partenaires étrangers et l'effort d'innovation local. Comment ces questions sont gérées dans votre organisation?

11) Parfois, la diversification des partenaires au niveau international peut accroître les possibilités de transfert de technologie et surmonter certains obstacles (dépendance), dans quelle mesure cela s'applique pour le développement des petits satellites en Algérie?

D. Suggestions finales

12) Comment qualifiez-vous les besoins des marchés, local et international, en termes de technologie de petits satellites (marché des composants et des systèmes)? Comment qualifiez-vous la tendance dans les marchés des petits satellites (évolution vers des marchés dominés par les fournisseurs, des marchés dominés par des acheteurs, etc.) ?

13) Selon vous, avez-vous d'autres marchés dont les besoins technologiques peuvent être satisfaits en utilisant les capacités qui sont en cours de développement et les connaissances qui ont été acquises (ex. aéronautique, technologies médicales, etc.)? Est-ce que vous envisagez de vous adresser à ces marchés?

14) Comment qualifiez-vous l'effort national en matière de développement de petits satellites de télédétection, est-ce que cet effort a été plutôt tiré par le développement du marché (utilisateurs des images satellites, etc.) ou est-ce qu'il est plutôt poussé par le développement de systèmes satellitaires (développement de composants et de systèmes satellites)?

15) Selon vous, quel est (serait) la direction des efforts algériens dans le développement de petits satellites, est-ce vers le développement de composants et de systèmes favorisant le remplacement des importations, ou bien le développement de composants et de systèmes destinés à l'exportation vers le marché international?

Appendix 3-a: Access to data and ethical considerations- Support letter

Date: 19 February 2016

To whom it may concern

PhD Research: An evaluation of satellite technology transfer to developing countries: A case study of Algeria.

Technology transfer from developed to developing countries is seen as a catalyst for accelerating the technological capabilities of developing countries. Space technologies, traditionally the reserve of the major powers, were not so much concerned with this debate. However, a new international dynamic has emerged over the two last decades. It consists in the rise of new international mechanisms, so-called satellite collaborative projects, allowing countries, such as Algeria, within a relatively affordable budget, to access satellite technology from abroad and start building their own satellite capability.

Mr. Ahmed AYAD is pursuing a PhD research on the evaluation of satellite technology transfer to developing countries, with an emphasis on the Algerian case. This research is funded by the Algerian Ministry of Defence.

As part of his research, Mr. Ahmed AYAD will conduct a fieldwork in order to collect empirical data from a population that is located in Algeria, UK, and France. Sets of interviews and questionnaires will be addressed to this population which is composed of individuals involved in the Algerian satellite projects, at technical, middle and senior managerial levels along with representatives of foreign companies involved in this process.

Beside the fact that this research allow better understanding of satellite technology transfer dynamics, it enables Algerians to gain appreciation on how effective are the mechanisms they used to build their satellite technological capabilities, and it provides guidance regarding effective processes to transfer satellite technology.

For these reasons, it would therefore be appreciated if you provide appropriate assistance and cooperation to Mr. Ahmed AYAD in his study.

Thank you

Professor Ron Matthews
Researcher's supervisor
Cranfield University - The Defence Academy of the United Kingdom
Shirvenham, Swindon
SN6 8LA
Emails: r.g.matthews@cranfield.ac.uk
Tel: +44 (0) 1793 785653

Appendix 3-b: Access to data and ethical considerations- Information sheet

Information sheet for participants partaking in the research interviews

Introduction:

My name is Ahmed AYAD and this research forms part of my PhD study at the University of Cranfield - The Defence Academy of the United Kingdom. You are invited to take part in this study. Before you agree to do so, it is important that you understand the purpose and nature of the research and what your participation will involve, if you agree.

Please read the following carefully along with the enclosed Consent Form. Please do not hesitate to ask clarification if anything is not clear or you wish to seek additional information. Contact details are provided at the end of this information sheet

For your information, the Algerian Ministry of Defence is funding this PhD research.

The purpose of this investigation:

This investigation is part of a PhD study aiming to evaluate small satellite capability-building in Algeria. This PhD value is to understand better the phenomenon of building small satellite capability through collaborative projects, and the effectiveness of technology transfer from developed to developing countries with regard to small satellite technology.

The investigation will provide empirical data that will be used in the PhD study. Sets of interviews will be employed to collect data from a population that is located in Algeria, in the UK and in France. This population is composed of individuals involved in the Algerian small satellite industry, at technical, middle and senior managerial levels along with representatives of foreign companies involved in this process. For these reasons, your assistance will be crucial in providing insight to explore this issue.

Do you have to take part?

Your participation is entirely voluntary. If you do agree to take part, you will be asked to sign the enclosed Consent Form. After your signature, you can still withdraw at any time before or during the interview, without giving reason. If you withdraw, any data that you have given will not be used in the study. The withdrawal will not have any ill-effects on you.

I will be interviewing you by myself. I will be the only person to hear you. However, you can allow any third person to be present during the meeting if you feel the need.

What will you do in the project?

If you agree to take part in the study and sign the Consent Form, you will be interviewed for about one and a half hours. The interview will take place in the location and at the time that are convenient to you. During the interview, I will be taking notes. Also, you will have the choice as to whether or not accept that the interview will be audio recorded.

Will my participation be confidential?

All interviews will be treated as confidential with only the researcher having access to the original data. Your identity will not be revealed and you will remain anonymous. For instance, you will be only identified as Participant A, B, C, etc.

The result from data collection will be incorporated into my PhD thesis. No participants will be named in any publication associated to the research.

In addition, upon your request, you can get a copy of the audio recorded interview or the interview transcript to review them.

Contact information:

Researcher contact details:
Ahmed AYAD
Cranfield University - The Defence Academy of the United Kingdom,
Shirvenham, Swindon
SN6 8LA
Emails: a.ayad@cranfield.ac.uk
a.ayad@asal.dz
Tel: +44 (0) 7466333647
+44 (0) 1793 785026

Researcher's supervisor contact details:
Ron Matthews
Cranfield University - The Defence Academy of the United Kingdom,
Shirvenham, Swindon
SN6 8LA
Emails: r.g.matthews@cranfield.ac.uk
Tel: +44 (0) 1793 785653

This investigation was granted ethical approval by the Cranfield University Ethics Committee

Appendix 3-c: Access to data and ethical considerations- Consent Form (English Version)

Interview Consent Form

A research project undertaken by Ahmed AYAD
PhD student in Technology Management,
Cranfield Defence and Security,
Cranfield University - The Defence Academy of the United Kingdom
October 2014 – Mars 2018

Interview with ……………………………………………………………….. (Please insert name)

- I confirm that I have received, read and understood the information for the above project and the researcher has answered any queries.
- I understand that my participation is voluntary and that I am free to withdraw from the project at any time, without having to give a reason and without any consequences.
- I understand that I can withdraw my data from the study at any time.
- I understand that any information recorded in the investigation will remain confidential and no information that identifies me will be made publicly available.
- I understand that parts of what I say may end up being used in an anonymised form in future research publications
- I consent to being a participant in the project
- I consent to being audio recorded as part of the project : yes / no

Please sign your name here:

Date:

Appendix 3-d: Access to data and ethical considerations- Consent Form (French Version)

Formulaire de consentement pour interview

Un projet de recherche mené par Ahmed AYAD
Etudiant PhD en Management de la Technologie,
Cranfield Defence and Security,
Cranfield University - The Defence Academy of the United Kingdom
Octobre 2014 - Mars 2018

Interview de .... (Veuillez insérer le nom)

- Je confirme avoir reçu, lu et compris les informations relatives au projet ci-dessus mentionné et que le chercheur a répondu à toutes mes questions.
- Je comprends que je peux retirer les réponses et données de l'étude à tout moment.
- Je comprends que toutes les informations collectées dans l'étude resteront confidentielles et aucune information, par laquelle je pourrais être identifié, ne sera rendue publique.
- Je comprends que certaines parties de ces informations peuvent être utilisées d'une manière anonyme dans des futures publications de recherche.
- Je consens à participer à cette étude.
- Je consens à être enregistré en audio dans le cadre de cette étude : oui / non.

Veuillez signer ici:

Date: