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CENTRE FOR DEFENCE ENGINEERING
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Armoured Vehicle Manufacturing in the Gulf States Challenges and Future Vision
A Systems Engineering Perspective

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Supervisor: Prof. Amer Hameed
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To My First Teachers

My Father Ustath Khalifa and My Mother Mariam

To My Beloved Family

My Wife Naseem

My children

Omar, Sara, Iman, Rufayda and Khalifa

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Commander-in-chief

Bahrain Defence Force

Lt-General Dhiyab bin Saqr Al-Nuaimi

Bahrain Defence Force Chief of Staff

And his assistances

Abstract

The armoured vehicles manufacturers (AVMs) in the Gulf States encounter many difficulties related to their current performance, their customers' circumstances and the interactions between them. The AVMs are Small and Medium Enterprises (SME), owned by entrepreneurs who manage their organisations intuitively, leading to likely performance degradation which affects their outputs and thus customer satisfaction. On the other side, the customers lack essential elements of the acquisition process such as the non-existence of published defence strategies documents, customer needs not being precisely clarified to the developers, demand fluctuation, customer individuals’ knowledge being insufficient to contribute toward developing the intended values, etc. Third, the interactions between AVMs and their stakeholders, the customer in particulars, do not rise to the level of product importance. These environments form the dynamic environment that AVMs in the Gulf states currently face besides other circumstances, such as the fierce competition worldwide, considerably changes regarding the threats and needs, constant technology advancements, and political challenges, which combined may hinder AVMs from attaining their instant (customer satisfaction) and future (market sustainability) goals.

Therefore, this thesis pursues aims to enable the owners/managers (entrepreneurs) of AVMs in the Arabian Gulf States to employ their resources efficiently to deliver innovative values that satisfy the needs of all of their stakeholders, customers in particular, within the dynamic environment. Dealing with the dynamic environment requires intensive planning and the execution of known managerial disciplines, such as strategy, supply chain and business to business (B2B) interactions along with utilising essential tools provided by the System Engineering (SE) discipline. The latter subject has adequate means to optimise the strategy and supply chain technical tools by integrating them with the related managerial tools to enhance the development efforts. Moreover, organised interactions among various related entities that share a well-designed network enforce the desirable integration and enhance the relationship in the B2B context which ensures customer satisfaction, confirms the AVM market’s sustainment, strengthens the defence industry and attains arms independence. These efforts must be monitored and controlled by higher national authorities’ substantial strategies to ensure that the national goals are achieved.

Therefore, the author suggests a conceptual model to guide all interested parties, the AVM's management, to enhance their performance by considering all essential managerial and technical aspects. The model also emphasises the importance of interactions in enforcing the applications of the strategic, design, production and test and evaluation process to enable AVMs to enhance their product development in order to capture customer satisfaction and succeed in business. The success of the national AVMs will lead to the attainment of one of the most important national objectives, i.e. arms independence.

Keywords:

SMEs, Entrepreneurships, national defence strategies, enterprise business strategy, supply chain, design concept, T&E, productivity, customer satisfaction, B2B, involvement, trust, commitment, System of system, soft system methodology.

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List of Abbreviations

AV	Armoured Vehicles
AVM	Armoured Vehicles Manufacturer
B2B	Business to Business
B2C	Business to Customer
BS	Business Strategy
CAD	Computer Aided Design
CATWOE	Customer, Actor, Transformation, Weltanschauung (Worldview), Owner and Environmental constraints.
CDOV	Concept, Design, Optimise, Verify
COTS	commercial off-the-shelf
CTQ	Critical to Quality
CURES	Cranfield University Research Ethical System
DFSS	Design for Six Sigma
DIB	Defence Industrial Base
DMADV	Define, Measure, Analyse, Design, Verify
DMAIC	Define, Measure, Analyse, Improve, Control
DMDOV	Define, Measure, Design,
DMEDI	Define, Measure, Explore, Develop, Implement
DOE	Design of Experiments
DS	Defence Strategies
EBS	Enterprise Business Strategy
GCC	Gulf Cooperation council Countries
GCC-AVMs	AVMs in the Gulf States
IDDOV	Identify, Define, Design, Optimise, Validate
IDOV	Identify, Design, Optimise, Verify
INA	industrial network approach
INCOSE	International Council on Systems Engineering
ISO	International Standard Organisation
JIT	Just In Time
KADDB	King Abdullah II Design and Development Bureau
KSA	Kingdom of Saudi Arabia
Leagile	Lean and agile
Les	Large Enterprises
MDO	multidisciplinary design optimisation
NDI	National Defence Industry
NDS	National Defence Strategies
NGCC-AVMs	AVMs in non-Gulf States
PADOV	Plan, Analyse, Define the candidate architecture, Optimise and evaluate, and Verify the system.

PESTEL	Political, Economic, Social, Technological, Environmental, and Legal
QFD	Quality Function Deployment
R&D	Research & Development
R&D	Research & Development
SC	Supply Chain
SCM	Supply Chain Management
SE	System Engineering
SEP	Systems Engineering Process
SME	Small and Medium Enterprises
SoS	System of System
SSM	Soft System Methodology
SWOT	Strengths, Weaknesses, Opportunities and Threats
T&E	Test & Evaluation
TQM	Total Quality Management
UAE	United Arab Emirates
UK MOD	UK Ministry of Defence
US DOD	US Department of Defence
VIPs	Very Important Persons
VOC	Voice of Customer
WOM	Word-of-Mouth

Nomenclatures

Armoured Vehicles Manufacturers (AVMs). These manufacturers provide protection means in the form of armoured vehicles and devices, such as bullet-proof vests for field soldiers and civilian VIPs. This focus of this thesis is armoured vehicles in their three developed forms: added-on armour on OEM vehicles, embedded armoured cabins on a premade chassis with necessary amendment, and bespoke armoured vehicles. Usually, such manufacturers are owned and managed by entrepreneurs and are considered as small & medium enterprises (SMEs), since these manufacturers might belong to big corporations or be part of many distributed workshops around the world.

Gulf States. The Gulf States include six countries, namely Saudi Arabia, the United Arab Emirates, Bahrain, Kuwait, Oman and Qatar. These countries are linked to each other by the Gulf Cooperation Council (GCC) which was established in 1981. Moreover, the GCC countries established the Peninsula Shield Force in 1984 to unite the efforts of the six countries towards defending the region from the threats emerging from Iran and Iraq. There have been tremendous initiatives to consolidate the acquisition of different arms among the six countries. The six countries depend to a high extent on oil as their main income and most industries are related to this field. However, some of the six countries have broken through to diversify their economy away from the oil industry.

Dynamic environment. Enterprises may face an unstable situation due to the continuous changes in the internal and external environments, including alterations that occur within the stakeholders. The dynamic environment transfers the enterprise from a stable condition to chaos and back again to a stable status, that does not last for very long. These evolving circumstances require enterprises to hire competent resources (human and capital) that can appropriately implement sudden changes in order to ensure customer satisfaction at both times.

Customer. The customers of AVMs are either military organisations or VIP individuals where the latter, in most cases, use the former to select and verify their needs - as VIPs are part of the nation’s leadership. Usually, the military organisation, in acquiring their needs, is represented by professional acquisition teams that play substantial roles in interacting with the providers’ members in a Business to

Business (B2B) form. The author of this thesis assumes that the customer and the publisher of the National Defence Strategies (NDS) belong to the same organisation, which is the national military organisation.

User. The users (usually military individuals) are part of the customer (military) organisation or the VIPs themselves. The users are the individuals who will be using the developed products after deployment and, thus, responsible for deciding their needs concisely; otherwise, the developed product will not match their real needs. The acquisition team, as well as the provider members, may help the users to overcome their difficulties in declaring their needs correctly.

National Defence Strategies (NDS). Documents prepared by the national defence authorities that reflect future military operations, especially issues that are related to securing the nation. Each country has its own arrangements of national strategies based on their hierarchy decisions in preparing themselves to defend the nation. This thesis refers the NDS to one of its essential strategies that control the acquisition of systems to fulfil the troops' potential needs, i.e. the defence acquisition strategies. The civilian authorities and private entities may cooperate with the defence authorities in deciding the appropriate NDS.

Business Strategy. Enterprises always in need of defined approaches to fulfil their goals. These approaches are selected from one or some of the well-known strategies such as the differentiation, low-cost strategy and focus strategies. The selection of suitable resources must follow the selection of strategies. These resources must be capable of executing the selected business strategy efficiently and effectively. Moreover, the acquired resources should have the capability to detect opportunities and threats which emerge suddenly concerning the existing dynamic environment. Therefore, the selected strategy and appropriate resources help to ensure the best development process and thus customer satisfaction.

Sub-system providers. AVMs depend to a great extent on various type of providers such as armoured plate producers and armoured glass suppliers. Moreover, the subsystem providers include those who can supply certain mechanical auxiliary equipment, such as shock-absorbers, turbochargers, advanced brake systems, etc. The combination of such a broad spectrum requires tremendous efforts when selecting both the suppliers and their production (the appropriate subsystem that can perfectly integrate into the main system). The changes that occur in one of these suppliers' products must be followed by the necessary changes in the main product.

Entrepreneur. AVM owners and founders can be considered as entrepreneurs, since they have sufficient passion to develop innovative products that cover the current and potential needs of military customers. They believe that such needs are significant opportunities which must be captured while accepting the risks associated with the dynamic environment. It is known that entrepreneurs are innovators who accept risks and enjoy rewards.

Developing process. The necessary process required to build up values based on specific needs and requirements. The process is designed and organised during an earlier stage, i.e. the design phase. The design phase, besides designing the product features, must guide the manufacturing resources to ensure optimum cost and better lead time. These two dimensions are reflected by two main performance factors: efficiency (minimum cost/waste) and effectiveness (the right time to finish the development process).

System of Systems (SoS). An AVM is a system which is a part of a network where each element within the network is another system that jointly works to fulfil the network goals. Each system including AVMs in the network is considered a system of systems (SoS). The SoS rests on two main concepts: first, the SoS reflects the existence of the dynamic environment as an evolved circumstance and, second, any changes that happen in any system or in the environment affect all of the systems within the SoS.

Business to Business (B2B). The trading relationship between two organisations (buyer and seller) is considered as B2B. The strength of the relationship between organisations depends on the reciprocal relations between knowledgeable individuals who belong to different organisations. These relations must be oriented towards enriching the interests of the two organisations. The B2B is enforced to help the SoS to reach its targets.

Design team. Differs from one organisation to another based on the size and business type. For example, small organisations may need a small number of individuals with limited skills while big organisations use design teams with high level skills and individuals with different functionalities. The business type also determines the size of such teams. For instance, organisations that develop new equipment may require a comprehensive team where organisations with limited manufacturability objectives may hire one or two individuals to work as one design team.

1 Introduction

1.1 Overview

The national defence industries generally aim to enforce national security while earning sufficient revenue to compete within their market of interest. Kurç (2017a) clarifies that much of the national industry’s success is due to the decision to strengthen national security. The national security objectives would be easier to achieve if these industries deployed strategies that were always aligned with the government or defence authorities (Kirkpatrick, 2008). In advanced countries, the government regularly reviews and publishes their development strategies based on potential threats and circumstances so that the industry can meet these development plans. Hodge and Cook (2013) claim that national defence agencies always seek adaptive systems that interact appropriately with predicted circumstances and environments. This allows the deployment of such systems as part of the overall defence strategy. However, each country has its own specific circumstances requiring different arrangements.

Piatkowski (2014), for example, distinguishes between the European Union (EU) and United States (US) defence strategies, as the former but not the latter relies on quantity over quality. Nevertheless, both approaches aim to acquire technology to conduct operations efficiently and effectively and, more importantly, save lives. On the other hand, according to Sokolov (2011), Russia failed in its attempts to imitate Western-style defence strategies due to the conditions in Russia at that time, which differed from those in the West. The defence strategy therefore significantly influences the approach used to secure the nation if the authorities take into account the specific conditions of their environment. Moreover, the defence industries must be aware of such strategies as well as any distinct national conditions.

Another example is Turkey, where the defence industry has evolved from being totally dependent on foreign suppliers to a major exporter (Kurç, 2017b). As a developing country, Turkey introduced defence strategies that would eventually make it independent, especially when the country faced several embargos during the twentieth century from their main arms supplier, the USA. Clearly, the Turkish defence industry’s policy was to “*increase domestic production through developing national weapon systems and technologies. The industry would be supported* *through investments and export incentives, although foreign partners were welcomed*" (Kurç, 2017b). Furthermore, some developing countries, such as Jordan, Saudi Arabia, United Arab Emirates (UAE), South Africa, Turkey, Malaysia and others, have already progressed towards the creation of defence industries. These movements enable these countries to reduce their dependency on politically unreliable arms sources. For example, Amara (2008) explains how South Africa and Brazil withstood US embargos by establishing their own defence strategies and industrial capabilities.

In some developing nations like the Gulf States, the critical activity discussed above is not the norm. As a result, there is a clear disconnect between defence strategies and the defence industries, especially national defence industries. This results in the inefficient use of human resources, skills and local industrial development for economic growth. The Gulf States have always been relying on foreign arms' suppliers to secure their nations. Furthermore, the area is mostly exposed to external threats from conventional forces such as Iran and Iraq and internal threats from terrorist groups. Moreover, the flow of arms to the Gulf States has faced stressful incidents from unpredictable political changes. These crucial reasons have led these countries to think on self-reliance in terms of arms. Luckily, the Gulf States are wealthy enough to dedicate a considerable amount of their incomes to build their local industries gradually, including the defence industries. Such attempts must be well-planned to transfer these countries from the current evolved situation to a new position. The unique situation can help mitigate the unexpected moves from industrial countries due to political issues, prosper the domestic economic status and finally maintain the national security unquestionable forever. These strategic plans should be a shared contributions of all local entities such as civilian & military authorities, private industries, R&D institutes, etc. The shared efforts of strategy planning may be extended to include regional governments and enterprises to enforce the regional (GCC) security. In the same context, the Gulf States share a defence treaty (Peninsula Shield Force) that has included all six Arabian Gulf States since 1984 (Tompkins, 2012), enabling them to share an NDS that combats threats quickly. These consistent circumstances encourage the six countries to unite in their efforts to establish a regional industrial network to enhance overall defence capabilities.

In this thesis, armoured vehicle manufacturers (AVMs) in the Gulf States are used as a case study to explain how a lack of defence strategies has resulted in the poor development of this sector, and insufficient support for local defence needs. Furthermore, the effect will be extended to include the AVM's business strategies combined with other circumstances related to the nature of AVMs in the Gulf States.

AVMs in the Gulf States are small or medium-sized enterprise (SMEs). There are few of them (29 in the UAE and 3 in Saudi Arabia)[1], and they are highly dependent on the intuitive and entrepreneurial style of their owners, with limited technical resources. Sten (2004) claims that such practices could harm SMEs due to the lack of a well-planned business strategy or at least the fact that their strategies, if available, do not cover the total activities of the enterprise. They are reliant on the management style of the owner to cope with the challenges of a dynamic environment and competition from large international suppliers, which are already well established and have the resources to sustain the challenges caused by changing user needs. Even so, the entrepreneurship of SMEs provides a stimulus for further innovation (Wierzbiński, 2009). This thesis will illustrate the influence of such circumstances on the performance of these relatively new industries in the Gulf States despite the lack of defence strategies, the management style, and other factors related to the supply chain.

To explain what is meant by a dynamic environment and how this affects the business environment, this thesis considers each AVM in the Gulf States as a system surrounded by continuously evolving conditions. The author supposes that these uncertain conditions result from many apparent factors that must be consistently addressed by management at all levels:

1. The absence of a published national defence strategy (NDS) that controls the defence industries within each country, cooperation with other countries, and any potential political risks.
2. AVMs operating in the Gulf States are more vulnerable to receive subsystems parts than ones operating from the same countries that produce the

[1] Collected from various resources.

subsystem parts. The political issues which may arise without warning play significant roles in subsystem parts flow.

3. AVMs are usually SMEs owned and managed by entrepreneurs, who often accept risks and pay less attention to systematic planning
4. The AVM as a system comprises different functional departments (subsystems) that require managerial integration. The organisational system leads to a product which is also considered a system composed of many subsystems involving technical integration. These two types of integration (managerial and technical) are essential to ensure robust values.
5. SMEs in the Gulf States experience intense competition from larger (national and international) AVM enterprises, which attempt to gain market share by addressing the limited demands of local customers. Another challenge is the ability of international AVMs to reduce average costs by leveraging economies of scale to offer state-of-the-art products.
6. Supply chain risks arise from the lack of managerial and technical essentials. An efficient supply chain requires managerial effort to minimise costs and reduce lead times despite the risks arising from the dynamic environment. Technical issues give rise to other challenges, for example designers must select the most suitable parts to achieve a performance that satisfies users based on their specific needs.
7. AVMs face uncertain demands due to unpredictable customer needs. Most AVM customers are usually from defence organisations that are sensitive to costs and production lead times.

These factors are summarised in Figure 1-1, which shows how unpredictable changes give rise to a complex, dynamic environment that strongly affects the performance of the organisational system (AVM), which consists of many subsystems (functions) needed to produce a product (system) composed of many subsystems (parts). Moreover, the factors that influence the system can inevitably interact to either increase or decrease the dynamic intensity. This thesis explores all aspects that can be used to either control the influencers or predict the changes, thus mitigating the associated risks.

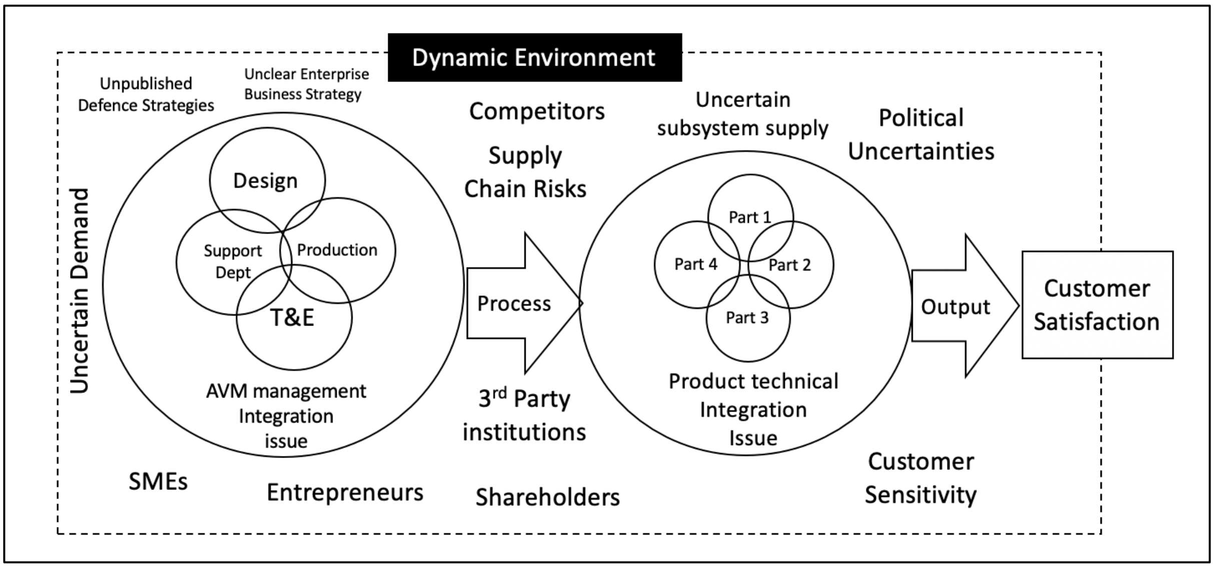

Figure 1-1. The complex systems considered in this thesis (Author).

1.2 Research background and context

Before conducting the research, the author of this thesis had worked for a long time with different AVMs and had developed the belief that numerous AVMs have been established worldwide to deliver high-quality products with special features while ensuring availability and reliability. The primary products are civilian and military armoured vehicles (AVs) but most AVMs also develop equipment for the security of VIPs and military personnel. Similarly, the customers of AVMs range from individual clients to organisations, such as defence ministries responsible for national security. The majority of individual clients seek customised solutions, whereas the needs of larger organisations depend upon the specific threats and national policies.

From an organisational and political perspective, the focus is quantity, performance, cost, reliability and operator/passenger safety. For individual customers, the focus is a customised solution that achieves safety and an elegant appearance. Both types of buyer might opt for commercial off-the-shelf (COTS) solutions or request a bespoke product in order to acquire the additional features that are unavailable in COTS products. In some cases, COTS products can be tailored to meet the necessary specifications. However, the costs should be determined in a healthy competitive environment where the providers, in conjunction with the customer, work as a team to compare different AVMs worldwide and strive to create a product that offers the best quality and value for money. According to Prempeh *et al.* (2008), the "*value for* *money (VFM) is derived from the optimal balance of benefits and costs on the basis of total cost of ownership*". In addition, it is critical that the quality of the end product should not be compromised by cost.

The technical and managerial approach described above could be achieved by applying the proposed managerial practices such as strategic management, supply chain management, quality management, marketing management, etc. that will guarantee the efficiency and effectiveness of future armoured vehicles. Therefore, this thesis views the problem from a systems engineering perspective to enable both researchers and the decision-makers to divide the problem into primary causes related to strategic aspects, the design concept, test and evaluation aspects, and supply chain aspects. These aspects are highlighted in turn below:

First, unlike large firms and their stakeholders, the hypothesis explored in this thesis is that the majority of AVMs do not undertake an appropriate strategic analysis to enable the planning of market sustainability and cutting-edge leadership compared to their competitors. Market sustainability and leadership arise by developing a better understanding of the customer's needs, and other operational requirements (Mariadoss, Tansuhaj and Mouri, 2011). If these are not captured well by the supplier, then the developed product will never deliver the expected value and will fail in face of future competition. Similarly, poor strategic analysis results in an incomplete list of user needs, leading to a product that fails to achieve customer satisfaction.

Second, when AVMs bid to win customer confidence, they must understand the customer's real needs and avoid ambiguities during early product development. This approach will not only guide the naïve customer but will also harmonise the entire development process. This type of industry mainly depends on other industries, such as the car industry, the manufacturers of armoured panels, armoured glass, wheel hubs, brakes and other ancillaries. This dependency is complex and AVMs therefore need greater awareness to produce a high-quality product. In fact, the success (efficiency) of the concept design phase is determined by the capability of the design team to convert the customer's needs, assuming that these are fully known, into specific engineering characteristics, which must be transformed into a physical end product through an efficient and effective managerial process. Moreover, the success of the design phase, which depends largely on the existence of a credible business strategy, influences the entire development process, including the production stages and test and evaluation (T&E) efforts.

Third, the AVM and the customer must agree on the acceptance tests covering well-defined T&E procedures and terms that enable the transformation of real needs into a specific product functions. In the absence of well-defined acceptance tests, the customer is forced to accept the vehicle according to the product specifications document supplied by the manufacturer, which may be based on unrelated or insufficient (unsystematic) T&E processes. Any deficiencies or shortcomings identified in the system during the T&E processes may lead to the manufacturer supplying a modified version that requires retesting or re-evaluation. The process for handling modified versions must be clearly specified and agreed by all parties. T&E requires thorough trials that must include the key players, such as the customer and supplier(s), including the subsystem providers or their representatives. In some instances, a third-party organisation must be included to witness and confirm that the trials comply with the standards or test procedures specified in the contractual documentation (Eigbe, Sauser and Felder, 2015).

Fourth, firms usually endeavour to acquire the best internal resources that enable them to develop the best product for a given market. Such a product is generally known as the core competence of the organisation. The core competence is defined as the responsiveness and efficiency of cross-functional business activities in creating and delivering innovative products and processes in response to technological and environmental changes. The core competencies are those activities that provide significant contributions to customers, that are difficult to imitate, and that provide access to markets across diverse sectors or locations (Bhamra, Dani and Bhamra, 2011). Therefore, acquiring the appropriate resources and maintaining and using them efficiently would position any firm at an advanced competitive level within the industry. Moreover, the selection criteria for sub-systems suppliers are important. These resources and applications form the backbone of the supply chain and must be aligned with the AVM's predetermined business strategy, robust design phase, well-organised production stages, and well-planned T&E.

To understand the problem and recommend solutions, this thesis will discuss each of the abovementioned aspects in an effort to enhance the quality of AVM outputs, in turn contributing to both the national defence and national economic sectors. However, these enhancements strongly depend on the establishment of robust defence strategies.

1.3 Research problems

This thesis focuses on the following factors that may strengthen national defence manufacturers and achieve independency for the defence industry (autarky). Business strategy, supply chain arrangements, design concepts, T&E and interactions among stakeholders are the main factors that any competitive manufacturer must consider to compete successfully in their domain of interest:

1. The availability of an NDS helps AVMs to align their business strategy with national defence requirements. This will enable AVM management teams to set appropriate plans and development policies in order to prepare resources and set further goals for the supply chain in which they operate.
2. A robust supply chain could help to design new armour concepts and novel technologies to deliver added value with the benefit lower delivery costs.
3. The supply chain requires a credible industrial network that includes different entities (sub-system providers, R&D institutes, external partnerships, and third-party quality-accreditation entities). This type of network is a priority to ensure appropriate defence strategies that fulfil military customers' needs effectively and efficiently.
4. Prior to this, manufactures must glean as much information as possible to develop a proposal that meets all customers' requirements. This information exchange can be improved by building significant relationships based on involvement, trust, and commitment. Therefore, organising focus days, workshops and one-to-one sessions are used to build confidence on both sides. This team approach achieved customer confidence from the onset.
5. Finally, Shamout (2016) considers customer satisfaction as a means to deliver economic value to the customer. This requires an appropriate supply chain in which the enterprise must strive to establish interactions with their

stakeholders through efficient communication designed to ease the flow of materials and deliver quality and value to customers in a timely manner.

In this thesis, customer satisfaction is therefore considered as an index to which each of the abovementioned factors can contribute, as illustrated by the conceptual model (see Figure 3-17). In order for AVMs to (1) succeed in the current dynamic environment of the Gulf States, (2) earn an above-average return, and (3) compete against other international AVMs, they must accept the challenge and manage their enterprises well by applying contemporary management practices and technical discipline. Moreover, this approach requires unique tools to optimally integrate all of the beneficial disciplines, which can be achieved by the application of systems engineering (SE).

1.4 Research questions

1. How does the NDS affect the strategies of local AVMs?
2. How does a well-prepared AVM business strategy enhance the enterprise performance and goals, customer satisfaction in particular?
3. How does a robust supply chain with a reliable industrial network and well-planned manufacturing process including design, production and T&E contribute to the AVM's customer satisfaction?
4. Which significant interactions can AVMs in the Gulf States adopt to enhance the relationships with their stakeholders and boost customer satisfaction?
5. How can AVM decision-makers use SE tools to enhance their ability to achieve customer satisfaction?

1.5 Research aim and objectives

Customer satisfaction is one of the indicators that confirm a product's ability to address customers' needs, promoting customer loyalty and thus the enterprise's profits and market sustainability (Ganiyu, Uche and Elizabeth, 2012). Therefore, enterprises must deliver two crucial factors: value and then satisfaction, where producing better values ensure customer satisfaction (Zhang, Zhang and Law, 2014). In addition, the inclusion of SE, where the spectrum is extended from the operational environment, through different managerial aspects, to the end product, and eventually to the stakeholders' expectations, leads the researcher to use its tools for guidance in many approaches, and as a learning tool to enhance the performance of the enterprise (Haskins, 2008).

This research explores the challenges faced by AVMs in the Gulf States due to the existing dynamic environment and develops a conceptual framework derived from the System Engineering disciplines where technical and managerial practices are integrated and optimised. Overcoming these challenges will enable AVM performance leads to enhance customer satisfaction, AVM market sustainability and enable the industry to help the nations to approach the national (defence) objective (vision), i.e. arm independency.

To achieve the above aims, the following objectives must be met:

1. Determine the significance of the relationship between the defence industry's strategies and customer satisfaction
2. Determine the significance of the relationship between enterprise business strategy and customer satisfaction.
3. Determine the significance of the relationship between the enterprise supply chain and customer satisfaction, assuming that the supply chain considers the industry network, design concept, productivity and T&E.
4. Determine the significance of using system engineering tools in enterprise management practices to ensure that overall national and enterprise goals are met.
5. Determine the significance of the interaction between AVMs and their stakeholders which activated through planned involvement, trust and commitment that lead to increase customer satisfaction?

1.6 Research approach

This introductory chapter is followed by an exploratory integrative literature review to highlight the influence of each factor mentioned above and to determine the contribution of each element to customer satisfaction. The study will first highlight the importance of the defence authorities' strategies to (1) identify national requirements in terms of arms, and (2) enhance the preparation of AVM business strategies. The literature review aims to produce a conceptual model that will facilitate the collection of data using appropriate empirical methods, i.e. scheduled interviews and questionnaires. The literature review, conceptual model, interviews and questionnaires are supported by the experience of the author of this thesis (auto-ethnography, and several visits to AVMs in the Gulf States before and during the research timeframe, as well as the collection of perspectives from key stakeholders).

The thesis considers AVMs in the Gulf States as a case study. Accordingly, two questionnaires were prepared, one for individual AVMs and one for customers. These were distributed via the Qualtrics platform (https://www.qualtrics.com), the respondents were reached via personal email, and the data were collected from the Qualtrics platform. The questionnaires were analysed using SPSS tools (frequencies and Mann-Whitney U-test) and discussed using explanatory methods enriched by further experiments and observations. One of the most valuable SE methods (soft systems methodology and learning cycle) was used to discuss the enterprise business strategy, supply chain (design, productivity and T&E), and interaction aspects to highlight the deficiencies and propose solutions for each element. The research will answer the research questions and offer recommendations.

1.7 Research structure plan

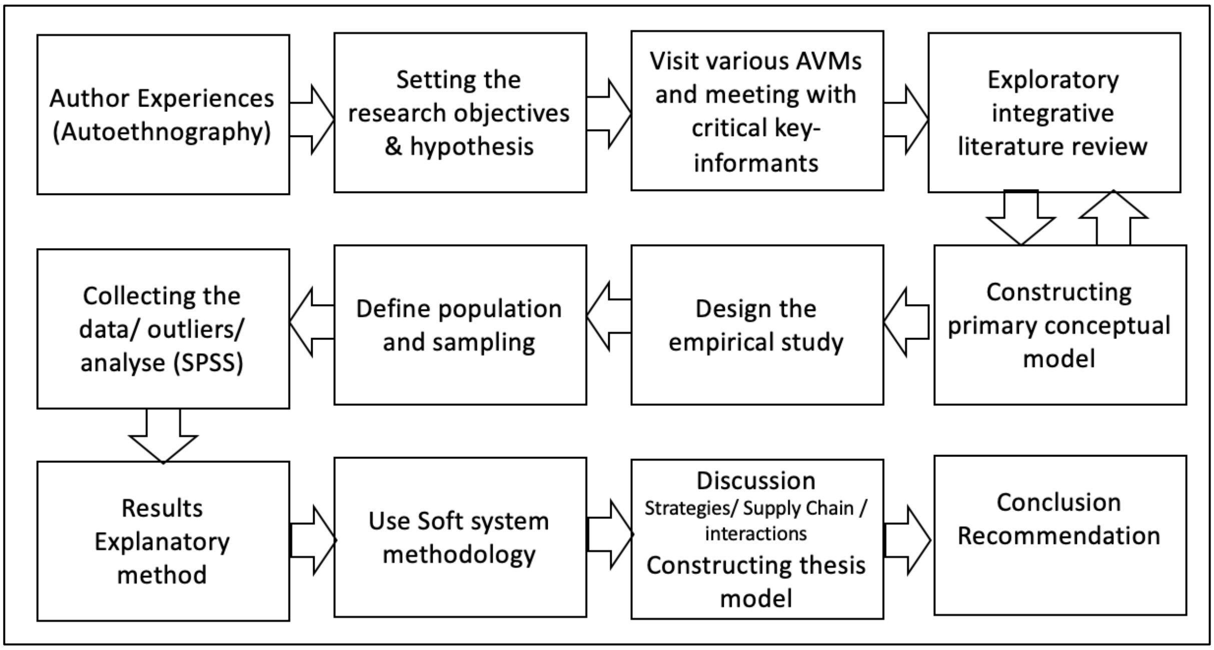

Figure 1-2. Structure of the research described in this thesis (Author).

1.8 Thesis outline

This thesis comprises four main elements: background theory, focal theory, data theory and contribution (Phillips and Pugh, 2010). First, the background theory highlights the most relevant theories that explain the latest achievements in the field and inspire further research. It also reveals the gaps addressed by the work described in this thesis. Second, the focal theory has two components: what the research is about and why the research is necessary. The focal theory helps to narrow the thesis objectives and generates the hypothesis and questions that are considered in the objectives. Third, the data theory deals with the way data are gathered and the reliability of sources to ensure high research quality. Therefore, the data theory comprises the methods used to collect and interpret the data based on the selected epistemology and ontology. Finally, the contribution compares the outcome of the research with the background theory using the data theory. Phillips and Pugh (2010) add that the four elements can be represented in seven divisions: Introduction, literature survey (background theory), methods (data theory), results (focal theory), discussion (development of focal theory and recommendation for further research), and conclusion and summary. The following sections describe the breakdown of the research into subdivisions (chapters):

1. Chapter 1. This introductory chapter describes the gap between the current situation of AVMs in the Gulf States and the ideal future situation where they enable the defence industry to prosper and fulfil national goals. The chapter sets some objectives and questions to fill the gap and recommends further studies as the research deals with evolving systems that cannot remain in one state for a long time. The chapter also illustrates the methods used to answer the research questions, outlines the thesis and summarises each chapter.
2. Chapters 2 and 3 develop the exploratory literature review. The literature review highlights factors that help stakeholders, especially AVM management, to guide their enterprises. Chapter 2 begins with strategic aspects of both categories (NDS and BS), with the former assumed to guide the latter. Furthermore, chapter 2 discuss the current situation of the Gulf States related to the defence industry and how to enhance such sector to approach the national preassigned targets.

3. Chapter 3 is the second part of the literature review (background theory) which describes the supply chain elements that contribute to the research goals. The chapter first emphasises the importance of the industrial network which enforces cooperation, collaboration and integration among different parties, and how to reduce risks associated with the AVM supply chain. The chapter also includes three prime phases that produce a reliable supply chain: the design concept, productivity and the T&E phases. These aspects have significant effects on the supply chain as well as the value added to the development process. Also, chapter 3 discusses customer satisfaction in business-to-business (B2B) environment because an AVM's primary customer is the defence organisations which are under the control of the defence authorities. B2B requires three elements to be addressed: involvement, trust and commitment. These social factors help to achieve customer satisfaction which ensures business sustainability and fulfils the customer needs. Furthermore, chapter 3 shows the importance of SE in enhancing the performance of enterprises, especially in a dynamic environment, by integrating various systems within and around the AVMs. SE provides tools that deal with the evolving system, which is a part of the research assumptions. The literature review is concluded with the conceptual framework, which includes all aspects that comprehensively lead to the research objectives and the SE tools which will be used in the discussion.
4. Chapter 4 describes the reasons behind the selection of methods. The selection was based on the research context and the best way to generate the data needed for research progress. The chapter discusses the benefits and applications of each method (Figure 1-2). A case study (AVMs in the Gulf States) is used to collect data through interviews, questionnaires and other methods. The chapter also explains the ontology and epistemology of the thesis objectives.
5. Chapter 5 describes data analysis, where the questionnaires, visits observations and interviews are integrated to achieve logical reasoning. Also, chapter 5 applies the 7-steps Checkland's soft systems methodology (SSM) to model AVMs in the Gulf States using one of the beneficial tools of SE as an essential part of the thesis data analysis.

6. In addition, chapter 5 combines and interprets the data to discuss the development process in the following sequence: strategy, supply chain, design, production, T&E and interaction. The proposed conceptual model is clarified with the 13 questions necessary to optimise the performance of AVMs to ensure customer satisfaction.
7. Chapter 6 concludes the thesis by highlighting the main research findings and answering the research questions and objectives. It also provides some recommendations for further research.

1.9 Chapter summary

This chapter has identified some of the critical deficiencies observed in the development and acquisition of new systems. The absence of defence strategies has resulted in poor interactions between the customer and supplier, and suppliers have never been able to understand the rational and critical needs of the user. Similarly, the user has never had the confidence to trust the supplier in order to collaborate in product development in a harmonised manner. To develop a better understanding between customer and supplier, and to enhance customer satisfaction in terms of product capabilities and features, this chapter has identified SE tools as an appropriate way forward. In addition, it has set certain objectives that will facilitate a better understanding of the factors that govern customer satisfaction.

2 Literature Review

2.1 Introduction to the literature review

This thesis deals with many approaches and disciplines that provide tools to enhance the performance of enterprises in order to fulfil their goals. The efficient implementation of such applications is most important if the enterprise produces vital products where customer satisfaction is the main concern. In addition, the competitive intensity challenges the management of AVMs to explore the environment and continuously prepare their resources, which correctly balances product quality and cost to achieve the optimum output (Su, Guo and Sun, 2017). The business strategy of the defence enterprise such as the AVMs lies between the authorisation strategies, i.e. national defence strategies, and performance of the resources. The national defence strategies help the national defence industries (AVMs) through various published strategies (with different levels) in order to prepare their enterprise business strategy which is necessary to build and control the resources needed to achieve the enterprise's goals, which usually helps the national defence authorities to achieve their national goals, fulfilling their military needs and achieving arm independence. This approach requires both the acquisition and hiring of qualified resources, known as dynamic capabilities, that ensure the optimum use of resources based on continuous assessment of the environmental situation (Wilden *et al.*, 2013). The dynamic capabilities require a reliable supply chain (locally, regionally and internationally) to ensure that the development process is proceeded as scheduled in an efficient manner. Furthermore, countries attract more businesses to their market through a desire to operate in a relatively stable environment and "*reinvent their business models*" (Demmer, Vickery and Calantone, 2011).

Therefore, the author proposes an initial conceptual model (Figure 2-1) which illustrates the sequence of product acquisition: defence strategies determine needs, which are accommodated by the manufacturer through a process of aligning its business strategy with defence requirements. This model will be developed into the final conceptual model which depicts, in addition to the primary process, all of the add-ons that affect the development process.

The initial model in Figure 2-1 illustrates the sequence of the literature review sections, which will culminate in the main conceptual model. The literature review, therefore considers the following aspects in sequence: (1) national defence strategies, (2) enterprise business strategy, (3) design concept, (4) production process (5) T&E, by outlining the supply chain, (5) the Business to Business interactions through involvement, commitment & trust and finally (6) system engineering and system of system tools.

Figure 2-1. The initial conceptual research framework (Author).

2.2 National Defence Strategies

2.2.1 Introduction

Because developing countries, including the Gulf States, have fallen behind in the defence industry compared to developed countries, they are more in need of national strategies with defined objectives concerning the defence industry and the intention to achieve independence in terms of armaments. These objectives would be customised based on the unique requirements of each country, but the Gulf States have many things in common and can only share one defence strategy. The lack of published national defence strategies in all Gulf States has led to ambiguity relating to the defence policies and defence industry in particular. Where a NDS has been adopted, it has played a significant role in securing the nation by defining potential threats and suggesting appropriate means (defence capabilities) to counter them. Here, the term NDS is used to indicate all strategies at different levels and various published documents revealed by the national defence authorities, whereby each country has its own specific strategy levels and designations. The NDS may not exist as a single report but may be addressed in various documents. The NDS in general relates to: (1) the potential national threats and ensuing military action, (2) the military capabilities that may be needed to withstand these threats and perform the proposed military actions, and (3) potential approaches to acquire the required systems by adopting a predefined defence system acquisition approach. An NDS can therefore be defined as follows (Taylor Group, 2016): It "*plays a key role in identifying the capabilities required by the war-fighters to support the National Security Strategy (NSS)".* Also, Hodge and Cook (2013) emphasise that the preparation and execution of a NDS helps defence agencies to acquire systems that can interact efficiently with all pre-determined circumstances and can be deployed to serve the national interest both currently and in the future, according to the frame-time predicated by the strategy. These two statements summarise the importance of the national defence strategies in defining the capabilities required to secure the nation and how to acquire the most appropriate capabilities concerning all related national circumstances. Through a well prepared NDS, all potential defence needs can be explored by industries (locally and internationally) which have the full capacity to offer the values that fulfil the predefined needs. Indeed, the current NDS should be prepared well to include the future needs in details which will be assessed later before preparing the next consecutive NDS. The period between two consecutive NDS can be determined by the defence authority, based on the country's exceptional circumstances (Defence, 2005). The author of this thesis believes that countries like the Gulf States, living in unpredictable dynamic environments with unexpected threats, should continuously monitor their surroundings and accordingly change their policies. The following paragraphs will illustrate the benefits provided by a NDS to developed countries, enhancing their defence capabilities and their relationship and cooperation with other countries. The Gulf States' authorities should seriously consider these benefits if they wish to reach arm independencies.

One can assume that the relationship between the NDS and the military customer is strong as the former reflects the latter users' needs. Figure 2-2 shows how DS regulations (produced by the customer) affect the business strategy of the manufacturer (enterprise) which controls the manufacturer's operations and product features/attributes, which, in turn, determine customer satisfaction (comparison between needs and product features). The emergent needs and shortages from earlier products (less satisfaction) are raised to constitute a new NDS, which will once again be conveyed to manufacturers that struggle to satisfy the customer.

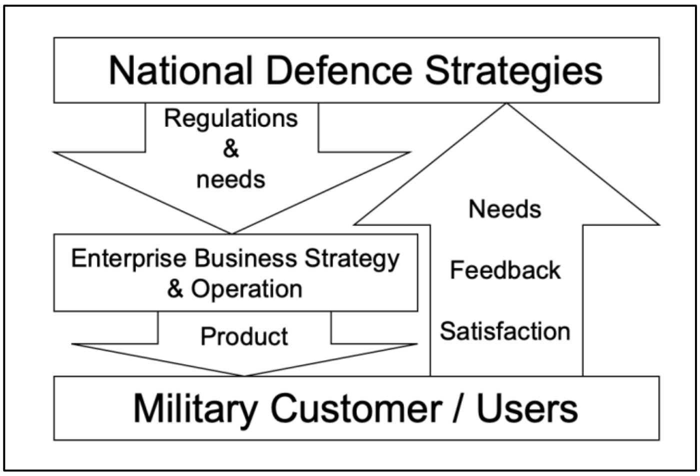

Figure 2-2. The relationship between NDS and customer satisfaction (Author).

2.2.2 The Contribution of the NDS

The importance of a NDS is clearly demonstrated in a white paper published by the UK Ministry of Defence (Ministry Of Defence, 2005). Accordingly, a NDS has many advantages. Firstly, it can strategically determine the defence capability requirements through either developing new systems or upgrading existing ones. Secondly, it clarifies any changes in financial and technological circumstances that may affect the upcoming acquisition of defence systems. Thirdly, the NDS coordinates with civilian manufacturers to develop and sustain desired national industrial capabilities. It is obvious that the NDS of the UK shows how the creation of defence strategies, one of the key aims of the NDS is helping to enforce the local defence industry by informing local manufacturers of different defence agencies' needs, specifying the type of product with respect to quality and cost, and increasing cooperation with national civilian manufacturers for the national interest. The author of this thesis recognises some benefits derived from the UK's Ministry of Defence.

Firstly, the NDS helps different industries, defence manufacturers in particular, to prepare their production capacity well in advance. The NDS brings the needs of soldiers in the field closer to the production line. Secondly, The NDS provides essential information that helps the related industries to accordingly develop the accurate values concerning trading off between cost and level of technology used. For example, such information provides clear guidelines about whether the national military agencies are seeking low-cost products, high-tech products or differentiation values. It guides both procurement and industrial decisions line. The UK's Ministry of Defence interpretation can be enforced by the Malaysian Ministry of Defence (2010), which states that the defence strategy helps in developing "*the capacity and capability of the local defence industry as well as defence science and technology*". In addition to the benefits observed in the UK MoD provision, the Malaysian MoD insisted on the interests that can be earned by the local industries after publishing their NDS. Therefore, a well-prepared NDS paves the way towards building a powerful national industry foundation. Amara (2008) concludes that the existing civilian industry will help to establish the defence industry. Moreover, the government authorities should create a balance between defence and private industries to prosper the national industry. He also contends that the national industries must be orientated towards state-of-the-art technology in order to compete with similar international industries. He added that the security situation in developing countries appears more promising regarding investing in the defence industry than in the past due to the increase in security threats.

Depending on onshore (local) private industries, they might offer many advantages such as diversifying the source of income to enhance the national economy (RSIS Indonesia Programme, 2013). Similarly, the Gulf States are now in greater need than before of diversifying their economy away from oil revenues (Schliro and Daniele, 2013). One way to diversify the economy is to encourage the establishment of industries that better serve the nation concerning the availability of the essential resources. The defence industry is one of these beneficial sectors that can secure the nation aside from diversifying the national economy (Gaub and Stanley-lockman, 2017a). Bitzinger (2017) affirms that countries are now more passionate about producing their arms locally for many reasons. Some of these reasons are to reach autarky, to assure "*security of supply*", to build up local know-how, and the fact that “*armaments production had come to be viewed as a critical component in the national economy*”. Bitzinger defined the advantages that most countries will gain from encouraging local industries to produce arms, and the Gulf States are no exception. Arms production will certainly help the Gulf States to diversify their economy based on the Gaub and Stanley-lockman argument. More advantages are identified by Balakrishnan (2008), who declared that “*recently, developing countries have begun producing arms for non-economic and economic reasons. Non-economic reasons for developing nations to pursue arms production include the need to overcome weapon embargoes. Political motives include considerations of foreign policy and the leveraging of military production for regional power recognition. Developing nations have recognised the benefits of building a defence industrial base that is capable of supporting self-reliant armed forces, further adding to their defence capability”*. The Turkish defence industry provides an excellent example of a defence strategy progressing towards defence autarky, i.e. arms sufficiency (Kurç, 2017b). According to Kurç, the Turkish defence industry has evolved from total dependence on foreign suppliers to the current situation, in which Turkey is considered one of the world’s main arms exporters. As a developing country, Turkey introduced defence strategies with the eventual aim of becoming arms-independent, especially when facing, in different periods of the twentieth century, the US as a major arms supplier and then US arms embargos. The Turkish defence industry policy was to (Kurç, 2017b): “*increase domestic production through developing national weapon systems and technologies. The industry would be supported through investments and export incentives, although foreign partners were welcomed*”. Kirkpatrick (2008) emphasises that such local industries give priority to the national defence agencies by fulfilling their requirements over external customers. Kirkpatrick adds more advantages that benefit the national economy such as increasing employment, promoting the nation’s technology, and continuously securing the supply of defence equipment, especially in the case of foreign supplies seized due to political conflicts. To promote an efficient onshore defence industrial base (DIB), Kirkpatrick (2008) insists that the national defence organisation must work hard to establish suitable defence strategies that benefit all stakeholders, including the higher defence establishment and domestic industries. In contrast to the above, it has been observed that countries like the Gulf States without an NDS miss out on these advantages, added to the fact that their future defence intentions are unclear to both their troops and their national industries. However, adopting and preparing such strategies requires the defence authorities to have insight into their specific environment. Gulf States currently depend mainly on external sources and some local sources but there is a huge gap between the two concerning state-of-the-art technologies in which a considerable amount of planned efforts is compulsory during the coming years. It can be concluded that all of the above critical points must lead the Gulf States to incubate the defence industrial base through establishing and publishing an NDS.

Besides having a credible NDS, countries should join a reliable consortia (Markowski and Hall, 1998). It has been recognised that it is very important to any country seeking to establish industrial sectors that require to help their local manufacturers to join reliable networks (locally, regionally and international) or struggle to establish one. including local manufacturers for many reasons. For example, Kirkpatrick (2008) highlights the four sources evaluated by the UK defence authorities for arms acquisition: government establishments, on-shore private contractors, multinational consortia, and foreign private contractors. The selection criteria focused on the current geopolitical, military, economic and technological environment. Ultimately, the UK defence authorities preferred to follow the onshore private strategy, which emerged from government establishments due to the lack of innovation capability and diseconomy. Even so, the UK defence authority may need to use some multinational consortia and foreign private contractors, which comes with disadvantages such as delays in meeting requirements because these enterprises will not be fully aligned with UK needs due to their non-UK or multinational customer profiles, respectively.

Cooperation among similar countries in the defence industry is essential to empower each nation that shares the union. Hartley (2006) explores one of the most efficient alliances in the world (NATO), describing the production of arms developed in different NATO countries based on each country's specifications. For example, France and the UK specialise in nuclear weapons and deterrence. Elsewhere, the Netherlands provides naval expertise whereas Greece, Italy and Spain focus on land forces. However, Hartley (2006) acknowledges some issues that could occur over time within such alliances, which the allied countries should take into account: Firstly, the conflict of national interests within such a comprehensive strategy and secondly, losing the knowhow of some industries that are developed by other countries. Lastly, an imbalance across different industries, e.g. the production of one aircraft is not like producing 100 armoured vehicles. However, EU alliances have addressed these problems by adopting the necessary defence industrial policies. In this regard, Hartley (2006) lists five principles that ensure an efficient defence industrial policy within NATO alliances. Firstly, Industries in all NATO countries are allowed to bid for defence contracts in all NATO countries. Secondly, NATO ensures that the number of specific arms requested exceeds the breakeven quantity to exploit economies-of-scale. Moreover, other NATO nations are invited to gain knowledge from the specialised nation source. Thirdly, the integration among NATO countries must avoid arms duplication where the R&D cost could be more efficiently allocated. Fourthly, changes in the environment of any NATO member encourage innovation and technical progress in which all nations will benefit. Fifthly, the high rate of production would lead to lower development costs. Thus, they will gain the ability to sell products to other countries at competitive prices. It has been recognised that the local NDS can be affected by neighbouring countries facing similar circumstances and might even lead to a common NDS if the cooperation between adjacent countries is very high, as seen among the Gulf States.

Although Kirkpatrick lists some of the consortia's disadvantages, the international consortia practice is a must. The Indonesian military has encouraged local industries to develop their capabilities to be able to cover the local military needs (RSIS Indonesia Programme, 2013). The RSIS report adds that "*the government needs to be flexible by placing emphasis on cooperative endeavour rather than championing the notion of autarky"* where international cooperation through reliable networks has become necessary for countries with infant industries. It can be concluded that the NDS must help local industries to select appropriate multinational consortia to enhance the national industry

Having consulted the relevant literature, the author has identified several lessons that can be learnt from different countries and regions with different geopolitical conditions. These examples, which are discussed below, offer insight into the strategies required for national defences in terms of both military capability and industrial performance which the Gulf States should consider in depth if they wish to benefit from the above-mentioned advantages. The Turkish experience is worth examining by countries that are seeking to establish their defence strategies and defence industries, and to achieve defence autarky. In this regard, Amara (2008) presents examples to show how countries such as South Africa and Brazil withstood US embargos by establishing their own defence industrial capabilities based on an NDS. They strived to achieve autarky even after rebuilding their political relationship with the US. They started to export their arms production and competed with developing countries in the defence industry. In fact, these countries have gained further advantages such as enhanced civilian industries, better job opportunities and more native human capital (Amara, 2008). To reach a high level of overall defence capability, developing countries must copy the experiments of Turkey, South Africa, and Brazil. The author quotes these examples to show that the situations of these countries were similar to the current situation of the Gulf States to prove that it is not impossible to follow their experiment toward autarky. Some developing countries, such as Jordan, Saudi Arabia and the UAE, have already progressed towards establishing a solid foundation for a defence industry, regardless of whether or not they publish their NDS.

Another significant issue, according to the author's thinking, is related to the size of the Gulf States' military forces compared to the nearest forces (Iran and Iraq) where the armed forces of each country of the Gulf States is far lower than Iran (most threatening) by a considerable ratio. This problem can be resolved by selecting qualitative (high-tech) arms which are necessary to compensate for the shortage of soldiers (Global Firepower, 2019) (see Table 2-1). In this regards, Piatkowski (2014) divides strategic defence intentions into two categories: quality and quantity. He defines quality as the need to acquire expensive, high-tech arms in low quantities to compensate for the reduction in quantity, and he defines quantity as a large number of arms that can cover wider regions at a lower cost. In this regard, he contrasts US strategies targeting of the quality of arms to EU countries that prefer quantity over quality, based on economic factors. Nevertheless, Piatkowski (2014) confirms that both strategies seek to acquire state-of-the-art technology to conduct operations that will enable nations to defeat the enemy with minimum losses. This fact is also clearly recognised in the Asian countries' defence strategies in enforcing their troops by acquiring quality arms with high-tech as described by Richard A. Bitzinger (2017).

These examples illustrate the importance of technology to overcome the shortages in manpower as is the case of the Gulf States' military forces.

Iraq	Iran	KSA	UAE	Oman	Kuwait	Qatar	Bahrain
165000	523000	230000	64000	425000	39500	12000	8200

Table 2-1. Active personnel in the Gulf States compared to Iran and Iraq (Global Firepower, 2019)

Another important lesson concerns how national circumstances can guide strategic preparation, so these essential strategies cannot merely be copied from other countries facing different conditions. In this regard, Sokolov (2011) claims that the Russian defence authorities failed in their strategies because they tried to duplicate the western NDS and apply it to their distinct environment. There are four principle reasons for this failure: firstly, the Russian economy differs significantly from the European economy in that the former is rigid where the latter has more flexibility with regard to encouraging local industries, especially on the side of innovation. Second, most Russian manufacturers are owned and managed by the government or government-private partnerships where the degree of productivity and human motivation are much lower than they are in Europe. Thirdly, the Russian government fulfils some of their essential needs from abroad by purchasing arms with state-of-the-art technology from France and the US, which has influenced the technological progress in Russia. Lastly, government authorities could not interfere with foreign companies, resulting in arms-export cases that lost many of their international friends who were key customers of the Russian industry. The Sokolov example showed that it is very important to sustain and develop technology within the country by establishing local manufacturers with sufficient capabilities concerning the special country circumstances. Similarly, the Gulf States have a unique ecosystem that is affected by many factors such as the high oil revenues, a distinctive geographic location, dynamic threats from different close sources, and with infant or no industrial essentials. These unique circumstances require a unique defence strategy that can sufficiently serve the Gulf States to fulfil their unspoken and published aims.

A valuable example in setting the appropriate strategy based on their special circumstances is provided by the Norwegian defence industrial strategies (Blom, Castellacci and Fevolden, 2013). This example is a good one to enhancing the defence industry in the Gulf States. The Norwegian authorities set two main objectives: to foster national economic growth through their defence industry to produce innovative products and compete internationally; and to support their local industry in three ways: make them the sole source for defence requirements, buy all spare parts exclusively from local suppliers, and support them to produce state-of-the-art products that will enable them to compete internationally. They add that the Norwegian authorities developed two instruments to achieve these objectives: an innovation policy that encourages local entrepreneurs to establish specialist enterprises; and a production policy to guide the industry to produce unique platforms that can cradle various complex weapon systems according to need. However, there is a trade-off between innovation to foster international competitiveness and the enhancement of domestic military capability which requires intensive attention from the higher authorities. The Norwegian experience has shown how infant industries can develop to compete internationally by adopting an NDS that encourages local enterprises to innovate and making them the sole source of future defence needs (Blom, Castellacci and Fevolden, 2013). Singapore is another example of encouraging innovation that offers a significant solution concerning their unique situation (Matthews and Yan, 2007). According to Taylor (Paul W. Taylor, 2019), the United States uses the "*National Security Innovation Base (NSIB)*" to enhance their national security and sustain their competitiveness. The NSIB needs to empower the national R&D capability and industry (Daniel Morgan, 2018). This innovation base indeed requires a reliable industrial network with an efficient flow of knowledge in order correctly to understand the national needs and use the state-of-art technology to serve their needs accordingly. The special circumstances require sufficient innovation. These three examples are significant in that they urge the Gulf States authorities to adopt innovation by establishing local R&D and encouraging national research efforts. It is vital to understand the geopolitical situation of the Gulf States through researches, which make a significant contribution towards identifying appropriate solutions to the critical position of these countries. Finally, the NSIB is a good approach for establishing a solid foundation for innovation and industrial sustainability.

Moreover, Kurç (2017) outlines how developing countries can achieve arms autarky by climbing "*the development ladder*" as shown in **Error! Reference source not found.**.

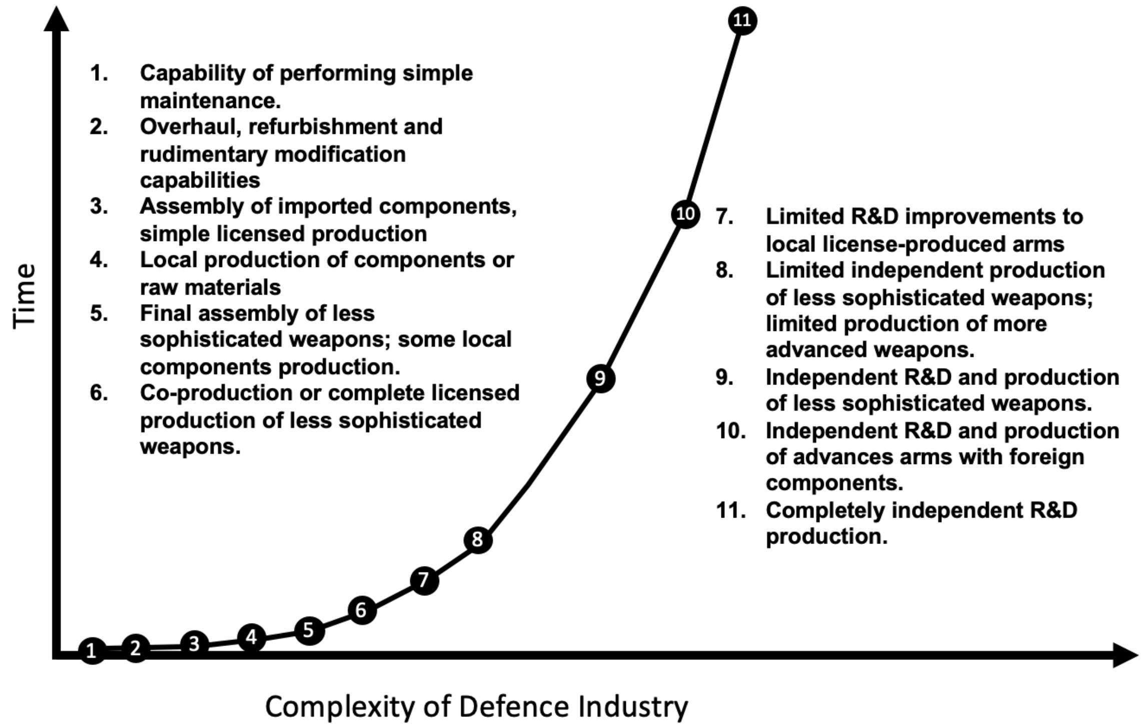

Figure 2-3 Time production of defence production (Amara, 2008)

This ladder starts with the ability to perform only simple maintenance jobs and progresses through a series of interim levels to the achievement of complete independence (point 11). The phases up until point 6 are very easy to apply and the defence industry becomes subsequently more complex and needs an adequate strategy if it is to proceed smoothly to point 11. Unfortunately, Turkey has been struggling with this development process due to the inevitable conflicts between the military and civilian elite, which have different perspectives on whether the defence industry or civilian industries can enhance the national economy (Kurç, 2017b). This conflict has affected numerous committees, which were established merely to push industry forward into the new millennium, when military political power has diminished and accepted civilian control. Since that time, the entire industry has been controlled by civilian authorities, which then allowed the military to control the defence industry while the civilian industries were controlled either by the government or the private sector. Nevertheless, the military has shared both government and private sectors to such as extent that it is able to wield considerable power in order to execute its defence industry strategies more effectively. Kurç (2017) shows how Turkey has climbed the development ladder and reach an advanced stage. He underlines that Turkey has invited foreign defence enterprises to join the national industries in joint ventures and partnerships, helping Turkish industries innovate to expand their market and thus increase their capabilities in terms of defence production. Moreover, the cooperation, co-development, and technical advice from foreign entities have enhanced national arms capabilities and created mutual dependencies between nations. Besides, Turkey has successfully identified more avenues for export by establishing better political relationships, particularly with developing countries. Amara (2008) refers to Krause "*ladder of production*" to show the progress of developing countries when enhancing their defence industrial capability. According to the author's experience in the field, it is obvious that the Gulf States are between phases 5 and 6 where the road towards point 11 requires well-planned strategies that target a certain year in a one- or two-decade period.

This literature review of national defence strategies clarifies some points that highlights the importance of the NDS to the country. Firstly, defence strategies are inevitable for all countries and it is more important for developing countries to establish and control their emerging national defence industries to overcome the risks generated by political issues. The defence strategy can also contribute towards developing the national defence capabilities of developing countries. Secondly, nations can foster their economic growth through innovation. The national authorities can encourage innovation through a suitable NDS to further support the sustainability of the local industry, enabling it to provide arms agencies with the products needed for defence (Blom, Castellacci and Fevolden, 2013). Thirdly, NDS enable developing countries to reach autarky and reduce the burden on the national economy by enhancing national technological infrastructure (Kurç and Neuman, 2017). Fourthly, defence strategies use appropriate systems acquisition policies to facilitate decision-making, diversifying arms-acquisition resources among available suppliers based on both political and economic situations (Kirkpatrick, 2008). Fifthly, NDS can encourage national entities to become part of multinational consortia that benefit all participants. The consortia can benefit all parties by applying economy-of-scale principles and developing systems that can be distributed among countries at lower costs according to specific requirements (Hartley, 2006). Lastly, NDS provide many advantages in addition to the creation of reliable national industries, such as civilian and military industrial development, job creation, and the development of local human capital.

2.2.3 Gulf Countries' aim to achieve arms independence

Despite its importance with regard to protecting the security of the region, the defence industry in the Gulf area remains in its infancy. This situation is the outcome of many issues that have led these countries to depend totally on external sources in order to acquire their arms-related needs. Political issues, a lack of domestic technologies and the weak industrial infrastructure have been among the leading causes of this. Recently, the Gulf States leaders have begun to devote serious consideration to the need to establish appropriate means by which they may finally be in a position to rely on themselves and have included this objective in their national and regional strategies (Vats and Serrano, 2016). This need becomes particular pressing in light of the fact that the US and UK - as the biggest arms suppliers to the GCC (see Table 2-2) – are facing uncertain political situations which may suddenly hamper the flow of new arms and parts of equipment that are currently in use. "*GCC self-confidence and assertiveness are rather new policy determinants necessitated by the regional strategic environment in which the Gulf collective finds itself*" (Etheridge (eds.), 2016). Unless the Gulf countries begin to consider producing their defence needs from this point in time onward, they will lose much more as the defence costs increase due to the emergence of unexpected threats in the region, the declining financial resources, and sudden changes in the political stances of the leading arms supplier countries ((Vats and Serrano, 2016). First, this paper will illustrate the Gulf countries' economic situation, before discussing the need to establish a domestic defence industry. Lastly, it will discuss the current situation and how this might be improved in order to achieve arms independency.

Rank	Country	Share	Rank	Country	Share
1	United States	48.1	2	United Kingdom	18.6
3	France	8.3	4	Spain	4.5
5	Russia	4.0	6	Italy	3.2
7	Sweden	2.7	8	Germany	2.7
9	Turkey	2.4	10	Switzerland	2.0
11	Canada	1.5	12	Netherland	0.9
13	Belgium	0.4	14	Others	0.7

Table 2-2. The Gulf States' Main Arms Suppliers (ranked in descending order) (Etheridge (eds.), 2016).

The Gulf region consists of eight countries, six of which form the Gulf Countries Council (GCC). These are: Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab of Emirates (UAE). The other two nations, Iraq and Iran, are not members of the Gulf Countries Council (GCC) (GlobalSecurity.org, 2017). The GCC was established on 25 May 1981 as a consequence of the growing threat caused by the Iran-Iraq war (Looney, 2003). According to Global Security (GlobalSecurity.org, 2017), "*These countries declared that the GCC is established in view of the special relations between them, their similar political systems based on Islamic beliefs, joint destiny and common objectives*". Iraq was excluded because it did not share such features and Iran is not an Arab country. This council has led these six countries to consider extending their cooperation in order to include many areas besides military cooperation. It is important to note that three of these six countries (Qatar, UAE and Kuwait) are considered among the tenth richest countries worldwide (Dennise Mccarthy, 2019).

Most of the GCC countries (Bahrain, Qatar and UAE) acquired their independence from British protection in 1971 (Sagynbekov, 2014) and Kuwait in 1961 (Nyrop, 2008), while Saudi Arabia (Wynbrandt, 2010) and Oman (Patterson, 2013) have never been under any protection agreement or colonization. Since that time, each country has started to "*invest in physical capital as well as in human capital, public goods and services*" to build their nation, including their military forces, with the assistance of developed countries (Sagynbekov, 2014). For example, "*Bahrain led the way, opening the Gulfs first aluminium smelter in 1971, operated by Aluminium Bahrain (Alba). Qatar followed by establishing Qatar Steel in 1974. In the mid-1970s, Ras Al-Khaimah Cement Company and Dubai Aluminium started operations in the*

UAE, and petrochemicals giant Saudi Basic Industries Corporation (Sabic) was established in Saudi Arabia" (Bains, 2009a). Although the industry was established in the early 1970's, it has not yet reached maturity within the GCC (Bains, 2009b). Hvidt (2013) claimed that the GCC's industry performance during the period 1973-93 was very weak, while several diversification attempts to reduce the dependency on oil were adopted during the 1980s. He adds that the aim of "*diversification was to ensure the creation of a viable economy that would sustain the livelihood of society in the aftermath of the oil era"*. Hvidt acknowledged that these attempts have had little effect in view of the high percentages of oil contribution to both export earnings and the total budget. Indeed, diversification liberates countries from depending on a "*one-side economy*" which exclusively depends on oil revenues (Ghandour and Diab, 2010). Unfortunately, depending on oil revenues would only develop the oil industry (Callen *et al.*, 2015). On the other hand, diversification opens up the local market to different industrial enterprises of various sizes (Hvidt, 2013). Diversification can also be achieved by promoting entrepreneurship through SMEs (Callen *et al.*, 2015). The Gulf States are at different stages of diversification, and the UAE economy is the most diversified among the six countries (Tadros, 2015).

Moreover, the GCC has been moving toward encouraging the private sector to join the public sector in an attempt to reduce the dependency on oil. Indeed, the high oil revenues are sufficient to enable governments to assist the private sector financially in addition to regulating the market to enhance the private sector's activities (World Bank Group, 2018). The objective is to help the private sector to guide and contribute towards a prosperous national economy (Hvidt, 2013). However, the process of depending on the private sector in the Gulf countries has been slow, according to a World Bank Group report (The World Bank Group, 2019). Currently, the six Gulf States are incubating around 17,000 manufacturers, 90% of which are SMEs, with a 5% annual growth. Saudi Arabia and UAE host the largest proportion of these (Jarzabek, 2016). This phenomenon will definitely steer the GCC economy away from oil revenues.

GDP is an influential gauge for understanding the power of the national economy. It is an excellent indication to investors, especially newcomers, regarding the possibility of the success of this economy in the near future (Investopedia Staff, 2009). GDP growth is another measure that indicates the status of a country's economy (Kimberly Amadeo, 2019). Table 2-3 depicts GDP growth during the past five years, during which the GCC market has offered a promising economy for local investors (entrepreneurs) to start a business and for reputed companies to extend their business to include one of the GCC states. Although there are negatives and low growth rates in some instances, the average growth rate indicates that the economic environment is healthy and continues to grow.

Country	Real GDP Growth rate %						Avg. GDP growth 2013-2018
	2013	2014	2015	2016	2017	2018	
Bahrain	5.42	4.35	2.86	3.22	3.89	3.20	3.82
Kuwait	1.15	0.50	0.59	3.55	-2.87	2.30	0.85
Oman	4.37	2.65	4.74	5.38	-0.27	1.80	3.09
KSA	2.70	3.65	4.11	1.67	-0.74	2.20	2.25
Qatar	4.41	3.98	3.55	2.22	1.60	2.60	3.06
UAE	5.05	4.40	5.07	2.99	0.79	2.90	3.52

Table 2-3. GDP growth in the Gulf states from 2013 to 2018 (The World Bank Group, 2019).

According to the EU Gulf Cooperation Council Investment Report (Commission, 2017), the investment climate in the Gulf countries is encouraging. The report explains some of the features available to foreign investors, especially those from the EU, such as the "*flexible tax regime on corporate income*", and the permission to "*operate with 100% foreign ownership*". Another potential advantage is the low customs tariff in the GCC, which reduces the cost of parts imported from offshore and so, in turn, reduces the final product prices. In addition, Oman and UAE established free zones, all parts that enter which are totally exempt from custom duties. The third factor is related to the labour regulations in the private sector which help enterprises to deal in a flexible way with workforce issues that ensure business success. Fourth, some of the GCC members have very strict rules against corruption, in which a healthy business environment is always protected. Therefore, is the GCC market suitable for incubating a defence industry?

The defence spending of the Gulf states is very high compared to other countries' spending relative to their GDP. It is estimated that the Gulf States' total spending has reached up to $130 billion in some years, where the defence costs were around $60 billion, which is a considerable amount of this expend (Mark and Fayek, 2017). Usually, the defence expenses are related to GDP in order to determine the importance of the security aspect in the view of the leaders and the arms required to withstand such threats. This intention was clearly recognized in the case of the Gulf States by the World Bank report (The World Bank Group, 2019) as shown in Table 2-4 and Table 2-5, the latter of which illustrates the amount of the defence costs, which exceeds that of the most powerful countries in the world, such as the USA, UK, France, Russia and China.

Exp/GDP %	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Bahrain	4.7	4	3.2	3.1	3	2.8	3.6	3.3	3.6	3.8	4.1	4.4	4.6	4.7	4.4	3.6
Kuwait	6.5	5.8	4.3	3.5	3.6	3	4	3.8	3.5	3.4	3.3	3.6	5	5.8	5.6	5.1
Oman	9.1	9	8.8	8.1	7.7	5.7	7	6.3	7.4	12.1	11.1	10.1	10.8	12	9.6	8.2
Qatar	2.4	2	1.8	2	2	2	1.5									
UAE	4.7	4.6	3.7	3.2	3.3	3.7	5.5	6	5.5	5.1	6	5.6				
KSA	8.7	8.1	7.7	7.8	8.5	7.4	9.6	8.6	7.2	7.7	9	10.7	13.3	9.9	10.3	8.8

Table 2-4. The percentages of the Gulf States' defence costs related to GDP (The

Country	Def Exp./GDP %
USA	5.2
UK	3.7
Russia	3.9
France	3.4
China	2

Country	Def Exp./GDP %
KSA	11.4
Bahrain	4.5
UAE	4.8
Kuwait	9.8
Qatar	19.7
Oman	9.6

World Bank Group, 2019).

Table 2-5. Comparison between the percentages of defence costs compared to GDP of the GCC countries and the most powerful countries in the world, based on the

average according to the available data during the last years) (The World Bank Group, 2019).

In this regard, Ghandour and Diab, (2010) identify three main factors that affect military expenditure: political, strategic and economic factors, which can be easily recognized in the case of the Gulf countries. The end of the Cold War led countries such as the USA, the UK to reduce their defence costs which affect their presence in the Gulf area. On the other side, the Iraq-Iran war and the Iraqi invasion of Kuwait increase the intention of the Gulf countries' leaders to allocate considerably more of their national income to defence sector. The political issues around the region have massively increased the defence costs. Strategically, the Gulf States require quantitative defence equipment to compensate for the shortage of soldiers in their armies, which is considered a strategic decision (trade-off). The qualitative means are more reliable than the quantitative ones with relatively small forces. Yet, more financial resources are allocated. Furthermore, the Gulf States are in the phase of developing their forces, after their dependence on other forces like Iraq came to an end due to the invasion of Kuwait in 1990. Furthermore, the USA's policy against some political issues with the Gulf States have affected the relationships between the Gulf States and the USA, leading to a dilution of the sense of permanent dependence on the USA to secure the Gulf region. These essential causes have led the Gulf States to think strategically when building their own defence industry infrastructure, like other countries, such as Turkey, Brazil and Malaysia, which have already progressed toward the achievement of such a goal, especially when one recognizes the financial capability of the Gulf countries to do so. Indeed, such an approach requires the acquisition of military needs from two sources in parallel: offshore purchasing and local manufacturing. The latter must gradually replace the former but there remains a demand to import technology from other industrial countries. This requires a well-prepared, established national strategy. Vats and Serrano (2016) admit that "*a strategic plan under the direction of national leaders and their respective Ministers of Defence will aim to build a defence industry ecosystem to meet the security needs of the GCC. This strategic plan will articulate a roadmap of defence capability programs and requirements from all stakeholders. The roles and responsibilities of each stakeholder will be clarified and governance tightened, so that each category of participant will be held accountable for meeting* *the industrialisation targets*". The third factor is the economic environment which appears promising, based on the given inputs.

Recently, two countries of the GCC, KSA and UAE, decided to dedicate some of their national financial resources to diversifying their economy by investing in the defence industry to prosper their economy on the one side and approach arms independence on the other. In Saudi Arabia, "*Vision 2030 unveiled the Kingdom's desire to raise local defence manufacturing from 2% to 30-50% by 2030*" (Gaub and Stanley-lockman, 2017b). One of the giant step in the direction of 2030 is the establishing of the Saudi Arabian Military Industries (SAMI) (Hani Hazimeh, 2017). Such new organisation should have some type of coordination with the existing industrial entities. Also, Gaub and Stanley-Lockman (2017b) describe the UAE attempt as: "*in April 2014, the UAE has made significant strides to become the leader of indigenous Arab defence industry development. The new conglomerate, EDIC, resulted from a massive merger between Mubadala Development Company (which maintains a 60% stake), Tawazun Holding LLC, and the Emirates Advanced Investments Group (EAIG). At present, the 16 subsidiaries that compose EDIC provide defence services, namely MRO, and also manufacturing of firearms, munitions and aviation components*" (Gaub and Stanley-Lockman, 2017). On the other side, they revealed that the UAE established "*strategic alliances with foreign firms allow younger defence industries to glean expertise and skills, gain access to sensitive technologies and intellectual property rights (IPR), and enter new markets*". These two initiatives have time frames decided by the higher authorities in the two countries, in which all national establishments work together to fulfil the initiatives' targets. The other four countries should follow the two examples and develop their industry foundations at the same pace. This synchronization helps the six countries collectively to consolidate their efforts by equally allocating the different type of production among them.

Despite the successful advances that both Saudi Arabia and UAE have already made, these steps must be complemented by further essential arrangements. In this regard, Vats and Serrano (2016) clarify that the defence industry plan requires six essential elements: "*strong leadership from the top of each government; an efficient and effective enhanced offset program; a well-coordinated procurement strategy; well-structured back-to-back OEM contracts; clear targets for the transfer of* *technology; and a plan for expanding domestic production with the eventual aim of building an export capability*". First, the nation leaderships should have a clear vision regarding how to achieve arms independence. The leaders must overcome the difficulties related to achieving the national goals. Second, countries that have been involving in offsets program in KSA since 1984, UAE since 1990 and Kuwait since 1992 must revise the current offsets' project and strive to overcome the obstacles to this. Third, the GCC military organizations need to create and follow "*a strong and workable procurement system*". For example, Turkey in 1970 succeeded in developing a policy and a committee that control both the offset and the local defence industry. Fourth, it is important to support the domestic contractors through paying their fees instantly. This essential financial arrangement would lead local contractors to pay their fees and survive in the market. Fifth, the GCC should work hard to transfer the technology to national individuals from different sources. Currently, the high-technology is transferred to expatriate labourers, who finally transfer such technology to their countries of origin. Last, the government authorities in the Gulf States should extend the local firms' market to include other countries outside the GCC region. Mutual agreements between countries would help to achieve this goal. Tadros (2015) urges the GCC leaders to introduce an innovation ecosystem "*whereby researchers and entrepreneurs collaborate and interact to promote commercial experimentation with different ideas and technologies*". Also, Tadros recognizes the low expenditure of the Gulf States on education and R&D as percentages of GDP compared to other countries (see Table 2-6 and Figure 2-3), where the GCC authorities should dedicate a considerable amount of their income to both fields, if they wish to enhance their industrial capabilities.

Country	Avg. % Edu./GDP
KSA	5.9
UAE	1.3
Bahrain	3.05
Kuwait	4.02
Oman	3.7
Qatar	2.5

Table 2-6. GCC Education expenditure as a % of GDP (The World Bank Group, 2019).

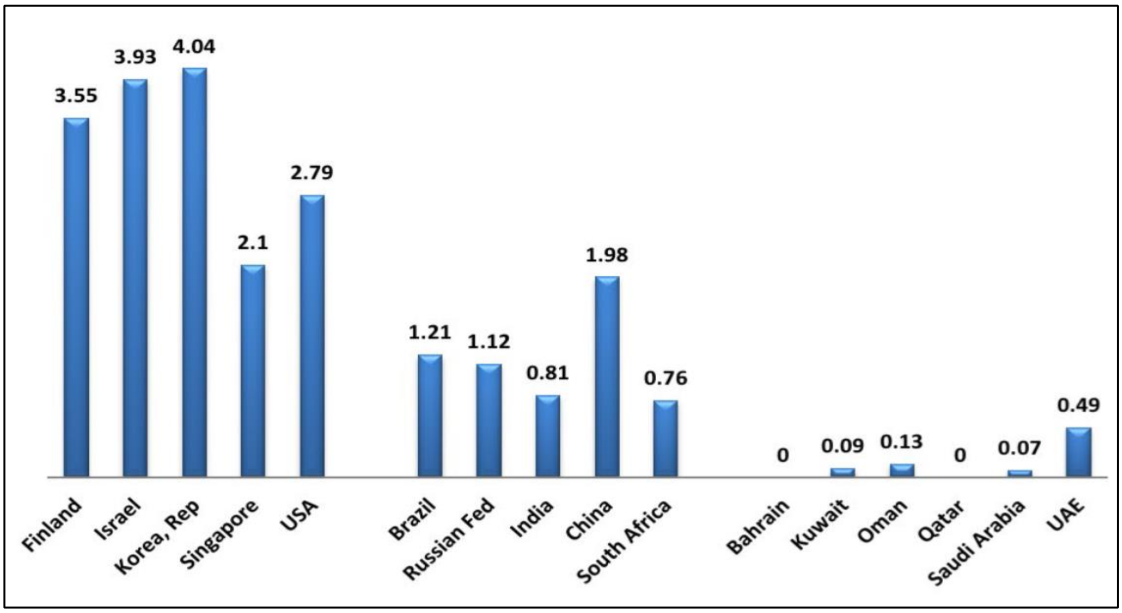

Figure 2-3. R&D expenditure as a % of GDP (Tadros, 2015).

In addition, Byat and Sultan (2014) list some of the essential recommendations that the UAE government should consider in order to improve its domestic industry through ecosystem innovation, which the other GCC can follow. First, the government should encourage innovation as a "*top-down push for innovation and prioritises key focus areas*". Second, governments should "*attract and promote talent*" by spending more on education and implement several cultural changes that will motivate the nation to contribute to education and innovation. Third, the higher authorities may activate partnerships with "*entrepreneurs, government entities, educational institutions, funds, the media, entrepreneurial organisations, and others*". These entities can help the nation to create a robust innovation ecosystem.

2.2.4 Summary

National defence strategies (as a group of documents published by the national defence authority) act as guidelines for the future needs of military agencies, and should be consulted by domestic manufacturers to develop a business plan. The managerial bodies of the defence authorities and local manufacturers must work together to align their strategies on the basis of national interests. In this literature review, the NDS was related to business enterprises strategies and thus leads to customer satisfaction. The NDS helps national enterprises to understand future national defence needs, elevate their resources for innovations, form robust national/international networks, and contribute to national aims related to arm independence. These activities require a strong business strategy and competent resources, which help manufacturers to achieve customer satisfaction. However, the Gulf States lack a published defence strategy which makes it difficult for enterprises to adjust to the requirements of the national defence authority. Finally, Section 2.2.3 discusses how the GCC States can transfer themselves from full dependencies on other countries to the self-reliance concerning the current conditions in the region.

The next section considers enterprise business strategy as the intermediary body between NDS and enterprise performance. Defence enterprise strategies must therefore comply with higher defence strategies in order to channel resources toward the fulfilment of enterprise goals, which ultimately contribute to national defence goals.

2.3 Enterprise business strategy

2.3.1 Introduction

AVMs in the Gulf States are newer than the mature AVMs in developed countries, which are the main competitors. Moreover, AVMs are SMEs managed by entrepreneurs who accept the risks of the dynamic environment and manage their resources without prior environmental evaluation and appropriate strategic planning. The lack of published national defence strategies in the Gulf States can dramatically influence the planning and preparation of local defence enterprises to produce strong values that achieve customer satisfaction. One can assume that national defence strategies are a key pillar used to generate credible enterprise business strategies, allowing national enterprises to establish themselves as defence manufacturers. The importance of an enterprise business strategy to achieve customer satisfaction is discussed below.

2.3.2 Strategic management concepts

As well as addressing national defence goals, a successful enterprise must establish a corresponding enterprise business strategy. AVMs in the Gulf States exist in a dynamic environment and desperately need a robust business strategy that enables them to generate profit and improve their values in order to support their national defence industry. Creating an enterprise business strategy relies on strategic management principles, which ensures success in today's dynamic and competitive environment (Mišanková and Kočišová, 2014). During the initial visits to AVMs in the Gulf States, the author has recognised that many AVM owners are unaware of strategic management principles so many dynamic environmental factors are overlooked. The benefits of strategic management tools as a means to capture customer satisfaction is clear (Ogrean, 2016): "*Tacit or explicit, value is one of the most powerful stimuli that energises the search for strategic competitiveness"*. He adds, *"The phase of the strategy and strategic management process* (*analysis of the internal and external environment, formulation of the strategy, and implementation of the strategy*)*, or the dominating paradigm regarding the very existence of the firm* (*for satisfying shareholders, stakeholders, society, etc. needs and expectations*)" must be inevitably respected by enterprises' owners and management to satisfy their customers in the dynamic environment (Ogrean, 2016). All of the above show a clear indication of the importance of using the role of strategic management in the selection of a suitable competitive strategy that will lay out the organisation's ultimate goals; leading to approach the national aims.

From the author's long experience with different AVMs in the Gulf area and the results gained from the initial visits, the following practices have been observed, as most AVMs in the Gulf States are SMEs managed by entrepreneurs, and strategic planning has a low priority for two reasons. Firstly, there are no standard rules that force management to perform regular strategic planning activities where intervention from higher authorities is required. Secondly, entrepreneurs usually manage their enterprises based on their intuitive ability which involves systematic and continuous environmental scanning. Nevertheless, strategic management scholars emphasise that in traditional strategic planning, the enterprise must first decide which strategy is suitable for their circumstances by analysing the current situation (internal and external) and business environment, the latter is defined as a set of political, economic, social, technological, environmental, and legal (PESTEL) factors that influence the business in both positive (opportunity) and negative (threat) ways (Roy and Singh, 2015). Another tool is the SWOT analysis tool (strengths, weaknesses, opportunities and threats). SWOT is consolidated in strategic planning as a primary form of analysis that not only checks the status of an organisation, but also its strategic position in its operational environment (Valverde *et al.*, 2015). However, a SWOT analysis may lead to a wrong decision if the management fails to apply it correctly (Phadermrod, Crowder and Wills, 2014). It is therefore necessary to apply this important tool correctly and systematically. In contrast, gap analysis is a tool that helps to compare the current situation with a potential or desired condition (Carollo, McKenzie and Leone, 2012),. By analysing and understanding the potential opportunities and threats, the strategic management then guides the management bodies to perform three essential interrelated process: strategic planning, strategic implementation, and strategic control (Mišanková and Kočišová, 2014). Ignoring one of these processes would lead to a failure (Gregory, 2007). The author approves the Gregory argument where the ignorance of these tools by the management bodies of the AVMs in the Gulf States leads them to underestimate the effects of the external environmental risks (dynamic environment) and failing to prepare the necessary resources (competitive resources) which would allow them to withstand uncertainty. As a rule of thumb, this fact is also applicable to AVMs in the developed countries. The author simplifies the strategic management process in Figure 2-4 which depicts the above contributions of many strategic management specialists.

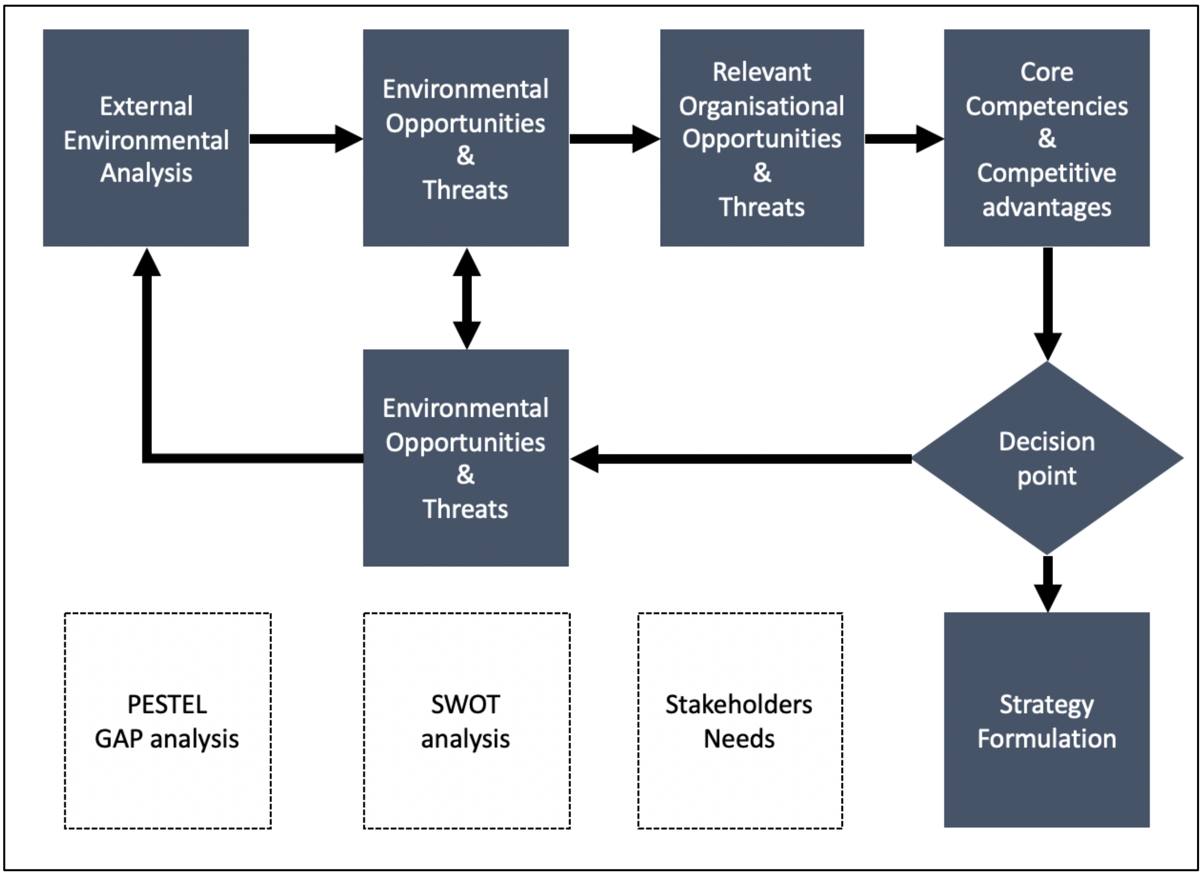

Figure 2-4. Strategic management tools (Author).

The author argues that the three above-mentioned processes, the third in particular, require competences that allow tasks to be performed within each process efficiently and effectively, especially by AVMs in the Gulf States that lack competent and empowered technicians because all operations are managed by one individual[2]. However, dynamic capabilities are needed to cope with managements' perception of changes in the external environment, which is considered a more dynamic approach because perception adapts to environmental changes (Ambrosini, Bowman and Collier, 2009). Thus, the management must renew, build-up (incremental) or regenerate their resources (in the case of a hyper-environment) based on their perceptions of change in the external environment (Figure 2-5). Ambrosini *et al.* (2009) define resources renewal as "*employed new resources are either created or introduced, or resources are combined in new ways*" while the incremental is a "*continuous improvement of extant resources*", especially when the environment is likely to be more stable. Regeneration, according to them, is necessary when

[2] According to the author's investigation during the initial visits and past deals.

"*managers perceive that the environment is turbulent, where external changes are non-linear and discontinuous*" (Ambrosini, Bowman and Collier, 2009). These dynamic capabilities create sufficient competencies for the enterprise to achieve a competitive position by ensuring it can react to the dynamic environment and maintain its performance, placing it in a better position than its competitors (Raduan *et al.*, 2009).

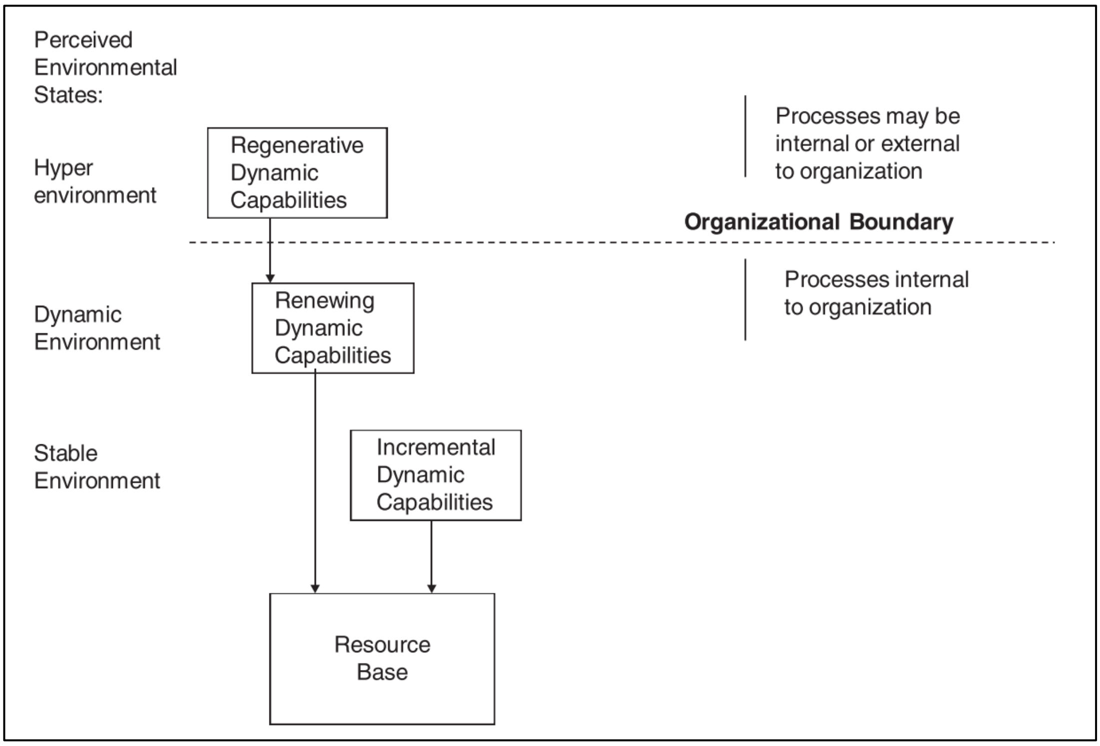

Figure 2-5. The three levels of dynamic capabilities (Ambrosini, Bowman and Collier, 2009).

Moreover, Breznik and Hisrich (Breznik and Hisrich, 2014) instruct the management to continue implementing both approaches, the incremental and renewal processes, to enhance the innovative ability within their enterprise as "*deploying innovation capability is one of the most challenging aspects of management*". The author considers the competition in the AVM industry is intense, especially when new AVMs in the Gulf States compete with mature international manufacturers. The author agrees with Ambrosini *et al.* (2009), Raduan *et al. (*2009) and Breznik and Hisrich (2014), that the strategic planning involves the acquisition of sufficient incremental, renewal, or even regenerated competencies, so enterprises (AVMs) endeavour to acquire what is known as core competencies by obtaining the appropriate resources that fulfil the enterprise's functions and infusing them with advanced capabilities.

The concept of core competency enables these enterprises to gain powerful attributes such as responsiveness, resilience, and efficient cross-functional business activities, so that they can professionally deliver innovative processes and products in response to external dynamic environments (Hsu *et al.*, 2014) where innovation is the essential key factor in advancing the local industry, as mentioned in the previous section. Core competencies can be defined "*as activities that provide significant contributions to customers, that are difficult to imitate, and that provide access to markets across different sectors or locations*" (Webb, 2014). According to Hoffman *et al. (2006)* "*a basic core competency becomes a distinctive core competency when it is something not only that a company does very well (a core competency) but something the company does better than anyone else in the industry (a distinctive core competency). This competency then becomes a competitive resource".* These two definitions reflect the ability of the core competency to close the space between the AVMs and their customers to achieve satisfaction through a distinctive core competency which the management must struggle to acquire. Nonetheless, Bhamra et al. (2011) declared that SMEs' managers are not fully aware of building their core competency, which certainly affects their future operation.

Core competency must be sustained and maintained (renewed, as shown in Figure 2-5) to avoid rigidity in the established approach and to eliminate or reduce any threat of losing the competitive position in the industry. For example, enterprises pay to recruit personnel (acquiring), pay salaries regularly (maintaining), invest in human resource training (developing), pay to buy machines and equipment (acquiring), pay for services and repairs (maintaining), and renew them (developing). Unfortunately, it has been observed that this is not the case with AVMs in the Gulf States as most of their employees possess a low level of technical skills and most of the innovative work depends on the managements' contributions,[3] which supports the argument of Bhamra *et al.* (2011) with regard to the SMEs, as AVMs belong to this category. It can be admitted that dynamic resources and core competencies are the most beneficial elements for AVMs, especially in the Gulf States, ensuring they achieve values that meet or exceed customer expectations and thus capture customer satisfaction. Moreover, such resources enable enterprises to stay in the market and

[3] According to the author's initial visits and past observations.

serve their customers longer. Nevertheless, such resources require appropriate strategies to steer them toward the enterprise goals.

2.3.3 Selecting the appropriate strategy

Environmental circumstances determine the most appropriate strategies to channel resources into the fulfilment of enterprise goals. The three well-known generic strategies are: low-cost leadership, differentiation, and focus. The low-cost leadership strategy forces the enterprise to use its resources at a lower cost than its nearest competitors. The differentiation strategy is followed when the developer tries to produce values that exactly meet the needs of certain customers more effectively than their competitors. While in the focus or niche strategy, the enterprise selects a few customers and serves them exclusively (Lynch, 2015). These strategies are referred to by Michael Porter as "*generic competitive strategies*" (Porter, 1986; Tanwar, 2013). Lynch (2015) defines the three main strategies available to managers where Porter and Tanwar (2013) consider them as a competitive approaches so that AVMs management might follow one, two or all the three strategies at the same time as they deal with different projects simultaneously based on the given circumstances. The author believes that the business success depends to a high extent on the strategy selection.

Despite the strategies described above, enterprises generally adopt a core strategy based on environmental circumstances, leading them to fulfil their intended goals. However, the selected strategy depends largely on available resources that have the abilities to execute the intended strategy efficiently (Bridoux, 2004). Figure 2-6 shows the strategies available to managements, depending on the particular circumstances, to ensure customer satisfaction and the fulfilment of national interests. The efforts of the enterprise may be directed towards improving performance, timeliness or economy by efficiently controlling the cost structure. At the same time, the enterprise management may wish to satisfy their shareholders by increasing sales and the return on investments (Hooley, 2004). Bridoux (2004) and Hooley (2004) emphasise the role of the management in selecting an appropriate strategy that enables the enterprise's resources to reach the predefined goals. The author refers to the success of the management in deciding the appropriate strategy to their ability in investigating both the external environment and understanding the type of available resources (internal environment). However, these efforts require management that is capable of performing environment scanning, strategy selection and leadership.

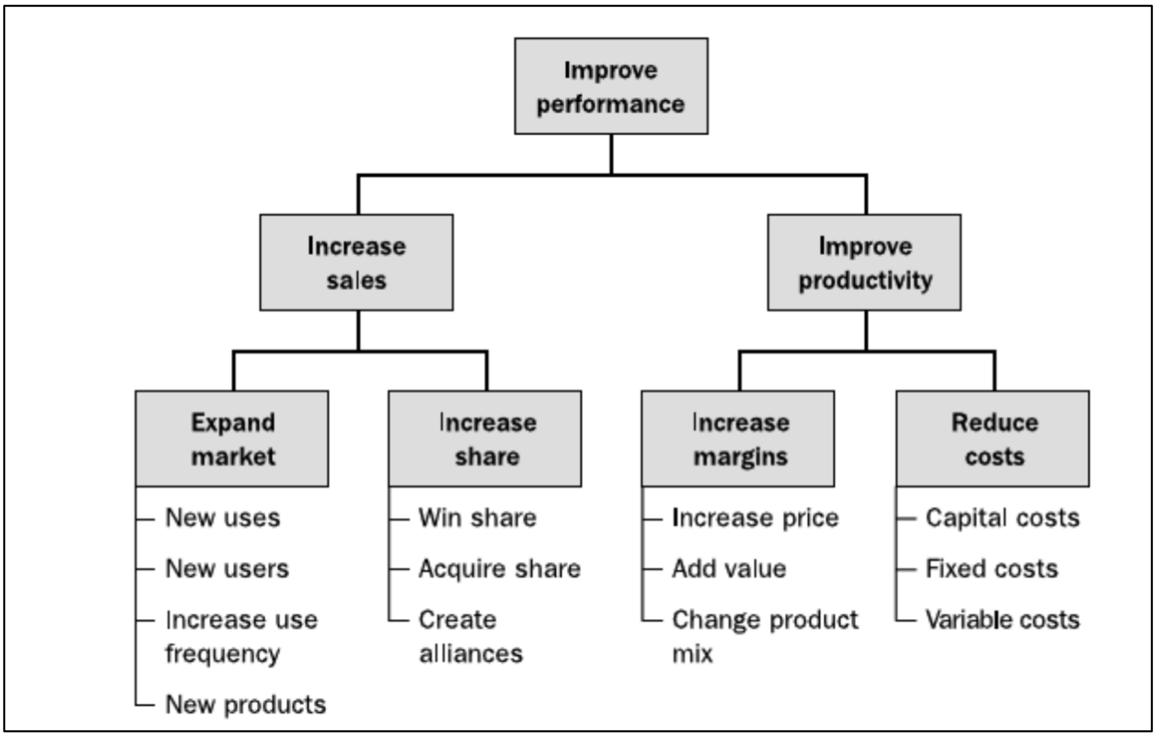

Figure 2-6. Core strategy (Hooley, 2004).

Finally, “true leadership” will help the enterprise to develop its vision and encourage subordinates to follow that vision. This treatment affects some stakeholders, especially the customers, because the leadership tries to generate high-value and innovative ideas, and cooperatively initiates the differentiation process, where innovation is the key word (Young, 2009). *Leadership is an important role which affects the success or failure of an organisation*” (Semuel, Siagian and Octavia, 2017). Dogan (2015) discusses how to consolidate entrepreneurship as a leadership style for strategic management as entrepreneurs can easily capture opportunities, create an innovative organisational culture and successfully lead their subordinates in dynamic environments. The author attempts to join leadership with entrepreneurship as both can be the attributes of an individual who is considered a key factor in AVM success. Terms such as leadership, entrepreneurship, core competencies, and competitive advantage must be in the minds of the AVM management when selecting and executing an appropriate strategy.

According to the author's experiences and initial visits to AVMs in the Gulf States, the most favourable strategy for these enterprises is the innovation. This strategy enables an enterprise to strive to "*design new products and launch more diverse products in faster development times than competitors*" (Drohomeretskia, Gouvea da Costa and Pinheiro de Lima, 2014). The author strongly believes that, if the AVM management can follow what Drohomeretskia *et al.* (2014) suggested, then success will be the ultimate result. However, this approach is not difficult for AVMs' management because they are owned by entrepreneurs who respect innovation and they are favoured by customers because they develop innovative ideas that match the customers' needs.

Moreover, enterprises may apply the dynamic entrepreneur's capabilities (DEC) concept instead of substantive entrepreneurial capabilities (Lanza and Passarelli, 2014). DEC enables SMEs to develop and deploy higher competences in pursuit of major technological changes. Teece (2012) stated that "*Entrepreneurship is about sensing and understanding opportunities, getting things started, and finding new and better ways of putting things together. It is about creatively coordinating the assembly of disparate and usually co-specialised elements. Entrepreneurial management has little to do with standardised analysis and optimisation. It is more about figuring out the next big opportunity or challenge and how to address it, rather than maintaining and refining existing procedures*". It is obvious that DEC can direct entrepreneurs away from standards to ensure business success through challenging the dynamic environment and decide the next stride intuitively and rapidly; this practices can be easily recognised in the AVM SMEs owned by entrepreneurs. In this regard, many authors have claimed that entrepreneurs ignore environmental scanning and depend on instinct to understand the relevant factors, then decide and act accordingly (Gedik, Miman and Kesici, 2015) where their outputs are unclear. For example, Babu (2015) explains that entrepreneurs think that they can see what others do not see (insight) and have an ability intuitively to discover what their customers need without prior analysis. This type of entrepreneurial approach may lead to success, or it may lead to disaster. Hence, the author insists that these efforts still require systematic approaches to ensure that all environmental changes are addressed with appropriate organisational actions.

2.3.4 Differentiation strategy and innovation

As mentioned earlier, there are three generic strategies that can benefit AVMs in different circumstances to approach their goals. However, enterprises have a wide choice when adopting a differentiation strategy, especially with regard to their products (Kotler, 2002). Differentiation is a way to ensure a sustainable competitive advantage (Mouillot, 2013). Moreover, differentiation encourages enterprises to explore the market and acquire that knowledge which leads to creating new features that eventually satisfy the customer (Su, Guo and Sun, 2017). By adopting such strategy, enterprises could select one or more options to achieve a value that perfectly accommodates their customers' needs, because these options are "*forms, features, performance quality, conformance quality, durability, reliability, reparability, style, design*". These options are always negotiable with the customer in order to reach a combination that satisfies all stakeholders (especially the customer) and also achieves the enterprise's wider goals. Indeed, innovation requires the sharing of necessary knowledge within and outside the enterprise in which the capabilities are established, and should be continuously developed for further innovation (Eze *et al.*, 2013). Thus, innovation is the result of engaging with potential customers such as military experts and other stakeholders such as subsystem providers who add value to the developed product in a learning process (Felin and Powell, 2016). This type of coordination requires intensive management support. Luckily, most enterprises owned by entrepreneurs tend to consider innovation as a major criterion for success (Ioniţă, 2013). From this intensive introduction, it is clear that AVMs may have only one choice to capture their customer satisfaction, selecting the differentiation strategy. According to Kotler (2002), differentiation offers more options for both customers and developers. Secondly, Su *et al.* (2017) and Eze *et al.* (2013) highlight the knowledge sharing among product developing participants. Thirdly, Felin and Powell (2016) specify the learning process that can enhance the participants' knowledge. Lastly, such learning process enhances the providers' competitive advantages, as noted by Mouillot (2013). These four crucial points are important for enhancing the national defence industry as knowledge is accumulated over time where future product features will be closer to the customer's needs

One of the most valuable solutions for SMEs to compete against large enterprises, is to adopt innovation, as a part of the differentiation strategy, that exploits the attributes of entrepreneurship. Innovation may be even more important for SMEs than large firms (Radas and Bozic, 2009). "*Innovation is particularly recognised feature of the SMEs because of their flexibility to the market changes. Innovative activities and SMEs are closely related, SMEs have to undertake innovative activities if they want to stay competitive, to develop, and to ensure long-term existence, in a dynamic and competitive environment*" (Fallis, 2013). Indeed, the author recognised that Radas and Bozic and Fallis linked SMEs to differentiation through innovation as the prime solution to counterbalance their size. However, according to Semuel et al (Semuel, Siagian and Octavia, 2017), these SMEs tend to increase the prices of their differentiated products to compensate the providing of new features. This fact may affect the customer satisfaction and thus, according to the author's thinking, it is the role of managements to balance between prices and quality. However, the question that arises: could AVMs in the Gulf States as SMEs offer differentiated values in competitive prices that satisfy their potential customers?

In fact, the implementation of a strategic innovation approach would improve the competitiveness of SMEs, and national authorities may play a significant role in this process. The key recommendations may involve encouraging talented people with a clear vision to start their own business; changing the terms of earlier financing methods; providing advice related to venture financing and strategic planning; supporting integration in the supply chains of large companies; and the internationalisation of companies (Milutinovic, Stosic and Mihic, 2015). These enterprises should incubate three types of innovation: technical, administrative, and product-related (Ejdys, 2014). Mendoza (2015) introduces the innovation in two types namely administrative and technical which is referred as a "*dual core model*". However, the combination of technical and process innovation depends mainly on how the enterprise owner (entrepreneur) deals with opportunities and available resources. Indeed, this provides more space for entrepreneurs to show creativity and use process engineering (innovative process) to achieve better practices and outcomes (innovative product). Some of the entrepreneur's core attributes and abilities include the ability to solve a problem, the presence of rapidly-changing problems, and the ability to change the way in which the company solves its problems (Zahra, Sapienza and Davidsson, 2006). Enterprises, through their owners, must therefore continue to search for innovations which promote business growth and the achievement of current and future goals (Loh *et al.*, 2011). Indeed, these five delivered statements provide significant evidence for the owners of SMEs like AVMs that accepting innovation as a strategy will help to differentiate their products according to their customers' constantly changing requirements. The author thinks that Zahra *et al.* (2006) have concluded five valuable contributions by saying that the management should have the ability to innovate and introduce a solution to all problems.

2.3.5 Strategic management dilemma

As mentioned earlier, many scholars argue that building a suitable strategy is not prioritised in enterprises led by entrepreneurs, because the decision makers do not realise the significance of the strategic approach, or are unable to establish one. Skokan *et al.* (2013) added that strategic management is overlooked reflects the fact that companies (SMEs) find themselves overloaded by operational tasks and have insufficient resources, allowing them to only partially and inefficiently fulfil their goals. Unfortunately, this was clear to the author of this thesis during his talk with different AVMs owners and management in the Gulf States. According to Skokan *et al.* (2013), enterprises can be divided into three main categories based on business development strategy: The first category includes enterprises with a detailed strategy including a business plan laid out in clear steps. The second category reflects those enterprises with a detailed strategic plan that does not cover all activities. The last category represents enterprises with no strategic plan at all or the strategic plan that is unknown to the stakeholders. The author can assign AVMs in the Gulf States to the second or even to the third category. Sten (2004) relates such deficiencies to the lack of infrastructure for developing a successful growth strategy and entrepreneurship style of management. It has been recognised that SMEs are the first and most prolific victims of a prolonged economic crisis, and are relatively deficient in terms of technological, managerial and human capabilities, for which adequate strategic planning is a priority. This fact confirmed by Raymond *et al.* (2010). The author thinks that the NDS may dictate that local manufacturers publish an updated business strategy that explains their intentions and capabilities.

In summary, the literature review of strategic aspects offers very essential points. First, the enterprise strategy links the NDS to the enterprise's performance, which enhances customer satisfaction, as shown in Figure 2-7. Second, the enterprise's strategy determines the type of competencies needed to seize opportunities and withstand threats. Moreover, the dynamic competencies are the core of any selected strategy. Third, regardless of the entrepreneurship management style, AVMs should be aware of the need to create a suitable nascent strategy that can withstand the dynamic environment in order to sustain in the market. The nascent strategy must be followed by the acquisition of efficient core competencies that can withstand the dynamic environment.

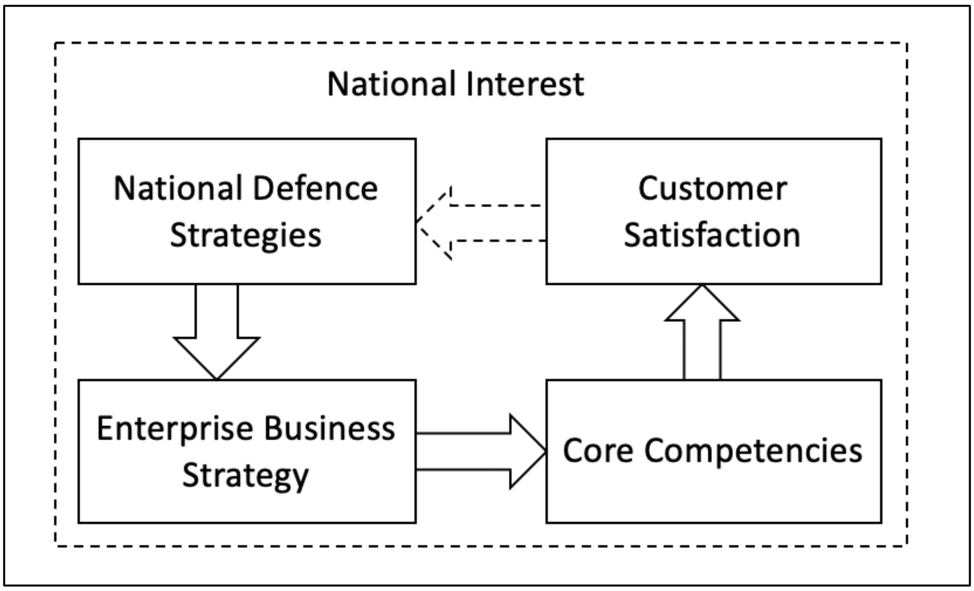

Figure 2-7. Relationship between the NDS, business strategy and customer satisfaction (Author).

2.4 The Role of the Supply Chain in Customer Satisfaction

2.4.1 Introduction

Section 2.3 highlighted the essential issues that AVM management bodies must consider before deciding which strategies are suitable to achieve their pre-specified goals and national goals. However, the execution of these strategies requires competent resources and reliable circumstances (including supply chains) that enable tasks to be completed efficiently and effectively. The author, during his investigations and due to his long experience of dealing with AVMs in the Gulf States, has recognised some critical issues that affect the reliability of the existing supply chain that feeds AVMs located in the Gulf States. The first issue is the absence of published national defence strategies in the Gulf States, which is one of the greatest factors that lead to having unreliable industrial network within the Gulf area. The second problem is the lack of a reliable supply chain network that can control the relationships among local manufacturers and essential entities in order to protect and maintain the national interest. This involves the lack of a credible pre-established network controlled by higher authorities, i.e. defence or/and governmental authorities. The third concern is the lack of interest in preparing and defining the appropriate enterprise business strategy, resulting in a lack of knowledge about the types of resources and competencies that AVMs need to perform their tasks. Last, lack of essential support bodies (third parties) such as R&D, T&E and quality assurance institutes. A poorly-structured supply chain network significantly reduces customer satisfaction and other key national and organisational objectives.

There appears to be a direct relationship between the quality of the supply chain and customer satisfaction (Figure 2-8). Shamout (2016) states that customer satisfaction is a significant motivator for the delivery of value in terms of technology and cost. This requires the building of an appropriate supply chain, equipped with adequate resources and intentional interactions with potential stakeholders: a competent supply chain that delivers value to customers by ensuring quality, timeliness and a satisfactory price. On the other hand, risks generated from being in uncertain (dynamic) environments hinder enterprises to acquire competitive advantages (Zhang *et al.*, 2011) where managements should create the possible avenues to mitigate or avoid such risks. Indeed, the creation of a trustworthy supply chain should mitigate risks, track the product's life cycle, reduce costs by well-planned outsourcing, and make immediate responses to unpredicted demands (Söderberg and Bengtsson, 2010). Shamout (2016), Zhang *et al.* (2011) and Soderberg and Bengtsson (2010) desire the management to understand and then deal (mitigate) with different surrounding risks by establishing well-planned interactions with the essential stakeholders to produce values in a short time (lead time) with less cost (better than their nearest competitors) to capture customer satisfaction. Hence, AVM managements are between two critical things, mitigating risk (lead-time and cost are part of risk) and satisfy customers where the former leads to the latter.

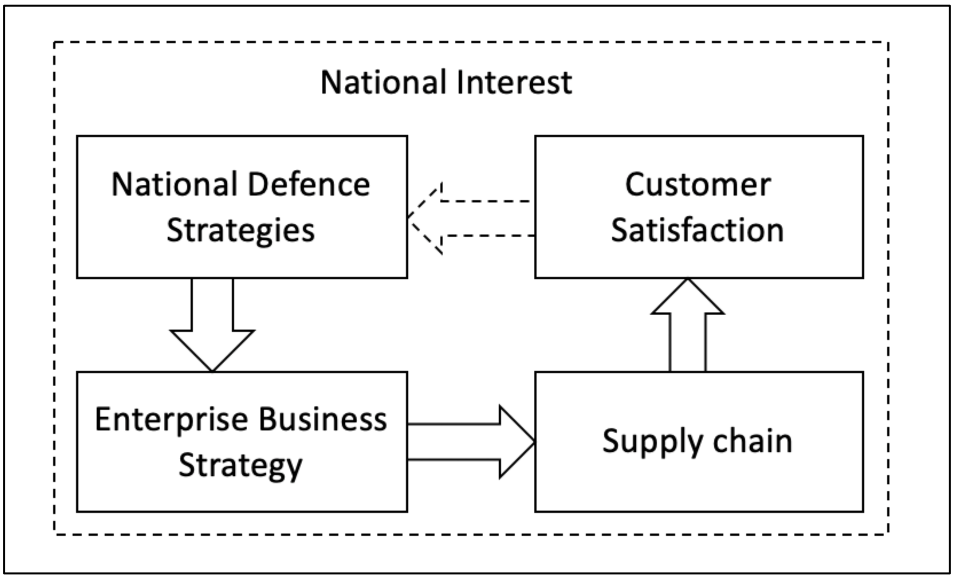

Figure 2-8. The relationship between the NDS, BS, supply chain and customer satisfaction (Author).

2.4.2 Supply chain and risks

The Supply chain management is a critical discipline which has recently emerged to overcome the sudden alterations in the dynamic environment (Melnyk, Narasimhan and DeCampos, 2014). Many enterprises consider the supply chain as "*a core strategic competence*" (Hsu *et al.*, 2011). Q. Long (Long, 2014) defines the supply chain as "*a network of autonomous or semi-autonomous business entities collectively responsible for moving a product from supplier to customer*". He added that these enterprises share a network with different and exclusive roles to collectively "*achieve competitiveness as well as their interests*". Wing S. Chow *et al.* (Chow *et al.*, 2008) insist that the supply chain is a holistic approach as it covers all coordination within and outside enterprises to reach the highest level of collaboration, cooperation and integration. Such tools are necessary to mitigate risks which are continuously generated from the dynamic environment. From the above selections, the author can underline some crucial terms that are necessary to AVMs' success, such as core strategic competence, holistic approach, collaboration, cooperation, and integration. These terms, which are essential for building a reliable a supply chain, are used to unite various autonomous entities to target their overall goals.

To acquire a credible supply chain, the type of risks must be known and addressed to avoid unexpected failures and ensure business success. Wieland (Wieland, 2013) lists some risks that are most likely to affect the enterprises supply chain such supply demand disruption risks due to supply disruption and demand fluctuation, risks due to the disruption of later-stage operations, risks based on alterations to the domestic legislation and/or international political issues, and risks of damage or gradual depreciation affecting operational infrastructure. While Corominas (2013a) identifies risk resources as risks "*coming from nature, from external human agents or from the inside of the supply chain itself".* Moreover, Ho *et al.* (2015) searches on all risks included in different articles and classifies risks into micro-risks ("*operational risks and miss-the-target*") and macro-risks ("*disruption risks and value-at-risks*"). The author of this thesis will rely on the Wieland classifications to present the deficiencies of the AVMs in the Gulf States. However, Ho *et al.* (2015) have differently interpreted where the "operation risk and miss the target" refer to production costs and lead-time, respectively. According to the author's experience, the disruption risks can also be recognised in AVMs if one understands that the needs are unclear from the beginning, and alterations are likely to happen during the development process. The next paragraph will explain some of these risks which clearly affect the AVMs in the Gulf States[4].

The first risk that AVMs in the Gulf State may face is the risk of demand fluctuation due to unclear acquisition plans of defence organisations and when the defence budget in the Gulf States is reduced, which has happened on several previous occasions. The second risk is the risk of supply disruption. This risk is high for AVMs in the Gulf State because they depend mainly on subsystem suppliers from countries with volatile international relationships with the Gulf States. For example, any embargo imposed by developed countries such as the USA, UK and Germany can affect the flow of subsystem parts to the production line, and almost all AVMs in the Gulf States rely on external subsystem suppliers. Another risk is the operational disruption. This disruption simply occurs with AVMs when a military customer intervenes in the development process to alter product features. Unclear military

[4] The author relies on his experience with AVMs in the Gulf states besides the initial visits and meetings with AVMs' managements

customer needs at the early stages of the development process increases the possibility of later alterations. The last risk is the catastrophic or natural risks, including natural disasters, socio-political uncertainty, civil turbulence and terrorist activities. Such risks are not considered major issues in the Gulf States since the Gulf climate is stable and the internal security always under control. However, threat from neighbour hostile countries is always expected.

AVMs could face some or all of the risks mentioned above because they exist in a dynamic environment in which management teams, especially entrepreneurs, must prepare themselves and their resources to deal promptly with such risks to avoid losing business. The discussion of strategy above (section 2.3) emphasised the need to understand all relevant circumstances to create a robust strategy along with strong policies and well-prepared resources to overcome known risks and mitigate against unanticipated risks by taking immediate action. For this purpose, supply chain scholars have introduced several strategies and tools that are discussed below.

2.4.3 Supply chain strategies

Dealing with risks entails, at the first level: generating credible information through the well-planned coordination of all stakeholders in a reliable network (Corominas, 2013; Garcia and You, 2015), and creating a robust supply chain with an appropriate structure that integrates intended behavioural relationships such as trust and commitment (Garcia and You, 2015). Therefore, to increase its reliability, the supply chain may include four types of integration: "*supplier integration, customer integration, boundary-spanning integration* (*the ability to communicate with the outsiders*)*, and internal integration*" (Jayaram, Kannan and Tan, 2004). In this regards, the most important forms of integration that positively influence product quality and thus customer satisfaction have been defined by (Lotfi *et al.*, 2013) are customer integration, supplier integration, internal integration and internal integration.

According to Lotfi (2013), customer integration can play a vital role in mitigating unexpected risks along the development process, from raw material supply to the delivery of value to the customers. Secondly, customer integration helps developers to build strong relationships with knowledgeable customers for future, mutually beneficial interactions. Supplier integration streamlines the operational, financial, and technical information exchanges between different product development activities and major subsystem suppliers. The integration of information by developers and subsystem suppliers contributes towards a collective decision-making style, enhancing the specific features and functionality of parts, because specialised suppliers know more about their parts than the main product developers, and better demand forecasting and inventory management. Lastly, the internal integration reveals the degree to which different skills in different departments and functionalities work in a collaborative, coordinated and organised manner to achieve production.

Referring to Lotfi's (2013) contribution and according to the author of this thesis knowledge, the customer integration in the AVMs in the Gulf States is not clear due to weak and unplanned cooperation between AVMs and their potential customers. Moreover, the supplier integration is very limited for two main reasons, the lack of defined subsystem selection criteria, where different projects might have different subsystem suppliers for the same part; and the relationship with subsystem suppliers is not organised efficiently. The internal integration depends on the number and nature of AVM employees concerning their multi-nationality, low-skills and high turnover. The role of AVM management/owners is therefore to conduct detailed investigations to find the most appropriate supply chain that sustains the forms of integration described above. Equally importantly, Melnyk *et al.* (2014) dictated that management must establish the best physical network that can unite all stakeholders and the most suitable social relationship for designing the required social network. In this context, Hsu *et al.* (Hsu *et al.*, 2011) stand on the social capital theory to enforce the supply chain especially between customer and supplier. According to them, the social capital theory helps to perform "*social networking activity"* as *"a strategy for augmenting their self-interests through mutual relationships*" (Hsu *et al.*, 2011). Liao and Kuo (2014) comment that social factors such as factors of "supply chain collaboration, *such as interaction, trust, and technological*" are essential to select the appropriate supply chain strategy. Such strategies require an intensive flow of information besides positive interaction. Melnyk *et al.* (2014), Hsu *et al.* (2011) and Liao and Kuo (2014) share the same concept of the type of strategy required to create a credible supply chain. They all affirm that having strong social bonds among stakeholders' rests on trust, intensive interactions and a sufficient amount of information decided by well-planned strategies.

Luckily, strategies at all levels (i.e. NDS and the business strategy of individual enterprises) can help to determine the best type of supply chain, which illustrates the strong relationship between strategy and supply chain management. Wieland (2013) discusses how management selects the appropriate strategies to control both the information and network in order to properly manage and mitigate the risks that affect the quality of the supply chain. In this regard, he identifies three types of strategies: agility, robustness, and resilience. These three strategies have been noted by Tukamuhabwa *et al.* (2015) as dealing with a dynamic environment with the presence of dynamic resources. Both Wieland (2013) and Tukamuhabwa *et al* (2015). explain that the agile strategy can be applied efficiently if the enterprise acquires dynamic or flexible resources that can be easily reconfigured to align with sudden changes in the environment, such as rapid changes in customer demand or delays in the subsystem supply. Wieland (2013) defines that the supply chain becomes robust if the resource can withstand or resist any "*disruption or deviation*" thus maintaining performance levels in diverse conditions. Thus, the robust supply chain requires redundant, reliable resources that have been carefully pre-planned to deal effectively with any disruptions. The last strategy is resilience, where the enterprise's resources can easily restore their capabilities to normal conditions after an unexpected event. Continuous experience of the resilience strategy can gradually create flexible resources. This learning process in turn builds the necessary agility and redundant resources, which confers robustness. In short, resilience is a combination of agility and robustness. Barroso *et al*. (2011) assign strategies to deal with disturbance to contingencies and mitigation approaches. The former approach is reactive while the latter is proactive. Both approaches require responsiveness capabilities with flexibility and redundancy resources. Flexibility capabilities can quickly reconfigure the existing resources along with changes in the dynamic environment. The redundancy approach, on the other hand, entails acquiring extra resources to replace any possible losses. Among all of the aforementioned strategies, the resilience strategy and flexibility resources can easily create and maintain a reliable supply chain.

According to the author's knowledge and initial analysis, the three above mentioned strategies executed by flexible resources are important to AVMs located in the Gulf States (dynamic environment) for many reasons. Firstly, AVMs need to build competent resources through a learning process. Secondly, AVMs need to react promptly to sudden changes in customer needs. Lastly, AVMs need to overcome problems caused by delayed or discontinued supply of subsystem parts. These three points can be approached by acquiring flexible resources within a collaborative network. Empirical research has shown that manufacturing flexibility, new production technologies, and close collaboration among partners (social networking) can improve supply chain responsiveness to mitigate risks associated (proactive) with the dynamic environment (Kim, Suresh and Kocabasoglu-Hillmer, 2013). The same study highlighted the positive relationship between responsiveness and customer satisfaction, because the manufacturer can react immediately to unexpected customer demands which, in turn, has a significant impact on customer satisfaction (Kim, Suresh and Kocabasoglu-Hillmer, 2013). The link between flexibility/responsiveness and customer satisfaction was also noted by Singhry (2015). He asserts that the use of appropriate manufacturing technologies would improve customer focus, thus leading to continuous improvement, allow effective cooperation with individuals both inside and outside the enterprise and also internationally, allow the acquisition of more knowledge about the parties to establish the most effective cooperation, and ensure that lessons are learned from previous collaboration experiences. Furthermore, Liao and Kuo (2014) relate customer satisfaction to collaboration, whereby all stakeholders, not only the customers, collectively contribute towards reaching a goal. Such collaboration requires a responsiveness capability within the enterprise. Therefore, it is important to highlight the above-mentioned SC's beneficial practices (responsiveness, flexibility, cooperation, collaboration, etc.) in enhancing enterprise performance and thus customer satisfaction.

In the same context, Zhang *et al.* (2012) introduced *Leagile Supply Chain*, which is a portmanteau of *lean* and *agile*. According to them, the *lean* concept helps the management to reduce all kinds of waste and associated costs, whereas the *agile* strategy enables enterprises to acquire flexible capabilities and quickly respond to sudden changes in the environment, thus meeting their customers' demands immediately. The *Leagile Supply Chain* rests on the idea of having a decoupling point (Figure 2-9) which distinguishes between the downstream customer requirements (agile) and the upstream (lean) manufacturing supply chain (Zhang, Wang and Wu, 2012).

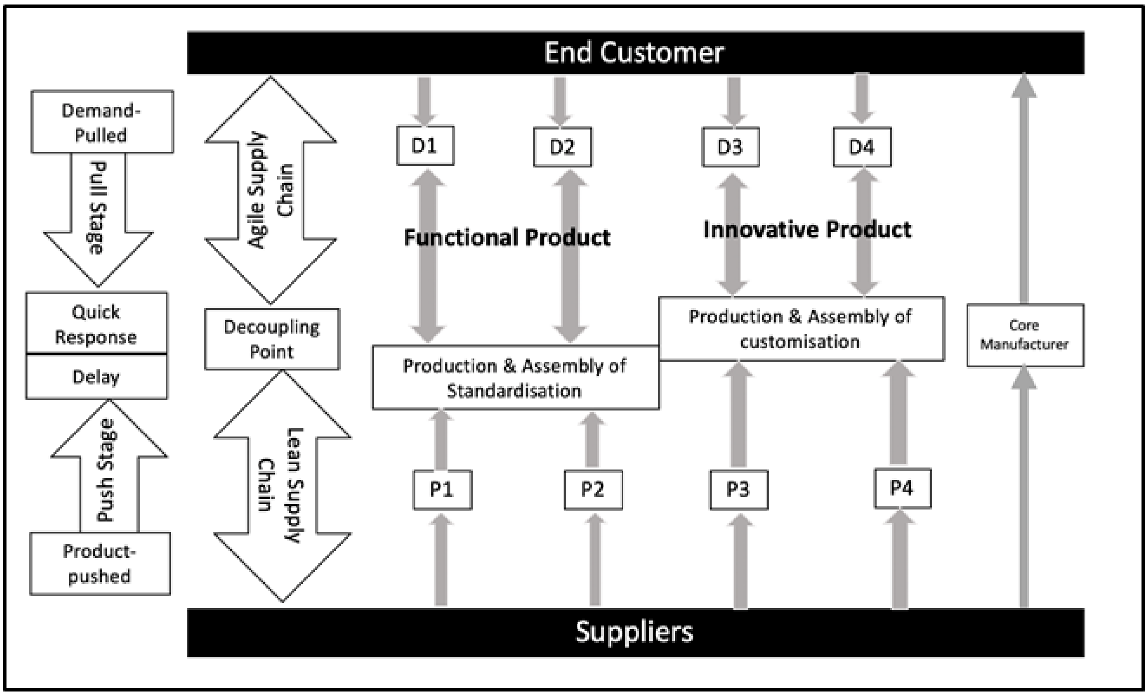

Figure 2-9. Structural model of the *Leagile Supply Chain* (Zhang, Wang and Wu, 2012)

Also, Zhang *et al.* (2012) assert that the *Leagile Supply Chain* can be applied to any enterprise (AVM) and offers the following advantages. First, information sharing along the supply chain. This can reduce some of the risks caused by incomplete information, weak relationships and poor cooperation among different enterprises and the inability to respond to market changes. Second, shortening of the supply chain which enforces direct communication with key customers to shorten the supply chain during certain phases. Third, manufacturers use the Leagile system to start production as soon as the customer order is received, and invite key individuals and customers to participate in designing the new product. According to Zhang *et al.* (2012), this practice helps to "*reduce the complexity of production, improve the efficiency of production, shorten the lead time, and satisfy the needs of end customers greatly*". Last, better cooperation among different enterprises that leads to more innovation and better integration with different suppliers. The author of this thesis believes that enterprise (AVMs) management has a wide range of strategies which are suitable for different situations, however, the availability of dynamic capability is necessary in order appropriately to deal with the dynamic environment.

Dixon *et al.* (2014) define dynamic capabilities as those resources that "*enable organisations to adapt, integrate and reconfigure skills, resources, and functional competences. They are 'dynamic' in the sense of enabling the organisation to renew its competences to achieve congruence with the changing environment*". The dynamic capabilities of a company (as a vital part of supply chain management) are strongly linked to innovation, which can be embedded in a resources-based review (RBV) to ensure that static resources become dynamic (Breznik and Hisrich, 2014). Innovative enterprises can adapt better to environmental changes (Boyett and Finlay, 1995). These capabilities must be associated with the ability to discover opportunities in advance of others by making continuous revisions to the dynamic environment, as clearly occurs in entrepreneurial practices (Wierzbiński, 2009). Dynamic capability can be divided into two main processes: adaptation and innovation. The management responsibilities in this context are to transfer resource capabilities from operational (adaptive) to innovative tasks, enabling the enterprise to use the available technologies and achieve the intended competitive advantage. The enterprise can then develop their resources and continue (learning cycle) to create innovative capabilities that ensure a competitive advantage. In the same context, Krzakiewicz and Cyfert (2016) propose a five-stage model, which sets out the innovation activities that lead to the acquisition of dynamic capabilities. The model begins with sensing opportunities, which involve exploring market needs by creating new ideas in order to understand changes in the external environment more precisely. The second is the learning stage which involves knowledge management within the enterprise, i.e. acquiring, allocating, and retaining essential knowledge. Knowledge is acquired either from external resources to capture new capabilities or from within the enterprise (lessons learned from experience). The third stage is the coordination, which involves efficiently integrating and managing all of the activities of stakeholders within the supply chain to ensure that the decision-making rules serve the vision of the enterprise and its stakeholders. The configuration stage follows the coordination stage, which involves managing resources and their capabilities. Moreover, resources are encouraged by their managements to share innovation and produce new technology. The final stage is the enterprise adaptation stage, in which the organisation gains adequate, dynamic capabilities to deal with external changes. The adaptation stage would enable the enterprise to withstand immediate threats, regardless of their intensity, and to capture most available opportunities before competitors.

Although a supply chain with the abovementioned attributes is needed to ensure the application of pre-defined strategies, the author of this thesis has recognised some crucial points that must be highly considered. Firstly, AVMs are SMEs with limited resources and they lack many of these attributes. Secondly, it is clear that the lack of an NDS (which increases the market sustainability of AVMs) has led management to avoid hiring qualified individuals and rely on temporary resources instead. Thirdly, the available human resources are not ready for advanced technical and managerial knowledge, limiting their flexibility and adaptability. Fourthly, the information needed to construct a robust industrial network is not clear because information exchange is limited to simple bilateral communications. Fifthly, innovation strategy helps meet customer needs but requires integration of personnel within the AVM and between AVMs and their subsystem suppliers and customers.

To overcome such deficiencies, Ambe (2010) confirms that managements of enterprises such as AVMs can adopt the systematic approach if they can ensure that all elements of the enterprise must commit to a paradigm that maximises flexibility and adaptability in the supply chain. Secondly, continuously reviewing and identifying factors that led to earlier problems in the supply chain allows lessons to be learned from mistakes. Thirdly, simple solutions should be implemented to address such issues, or systematic concepts must be used to solve complex problems. Fourthly, information inputs from different functions that help to achieve greater flexibility and adaptability are needed to enhance the supply chain. Fifthly, centralised responsibility is necessary to review plans for change. Lastly, the management must be open to new theories concerning the supply chain and must convince their chain of command to implement those theories and enforce the coordination between the different elements of the enterprise and both customers and suppliers. One of the valuable solutions is applying the system engineering discipline to the supply chain, as will be introduced in the next section.

2.4.4 Systems engineering and the supply chain

Thomé *et al.* (2016) describe the supply chain as a complex system which involves internal, supply, demand and external integrations and uncertainties. The systematic approach enables the management to deal with each subsystem individually and collectively. "*In other words, we defend a systems view of supply chain resilience since, in many cases, the effort of mitigating one type of disruption might initiate another disruption elsewhere*" (Spiegler, Naim and Wikner, 2012). These two arguments confirm the necessary of applying system engineering to the supply chain as a dynamic system that is affected by related systems (internal and external).

To clarify how SE can improve the supply chain, Vrijhoef and de Ridder (2007) define four main systems: the social, economic, production and organisational systems as shown in **Error! Reference source not found.**. The number of these elements shows how SE deals with complexity by embracing all factors and discussing them both individually and collectively. Indeed, the SE approach confirms the logical configuration of the supply chain, which can improve the enterprise's performance by enhancing the integration of established interactions. For example, the supply chain should integrate its prime components, such as the customer and subsystem suppliers, to ensure optimum production efficiency and effectiveness (Vrijhoef and de Ridder, 2007). The most critical part of such a framework is the social perspectives where the integration is strengthened through communication, trust, embeddedness, learning and alliance.

A "*demand system integrator*" and a "*supply system integrator*" are recommended to cover all of the elements in **Error! Reference source not found.**, as follows (Vrijhoef and de Ridder, 2007). The demand system integrator where the customer plays the key role in establishing the supply needs, where all preceding stages depend largely on the comprehensiveness of the delivered needs. The supply system integrator relies on the integration with subsystems providers which also requires intensive preparation to ensure "project-independent collaboration" within the supply chain (network).

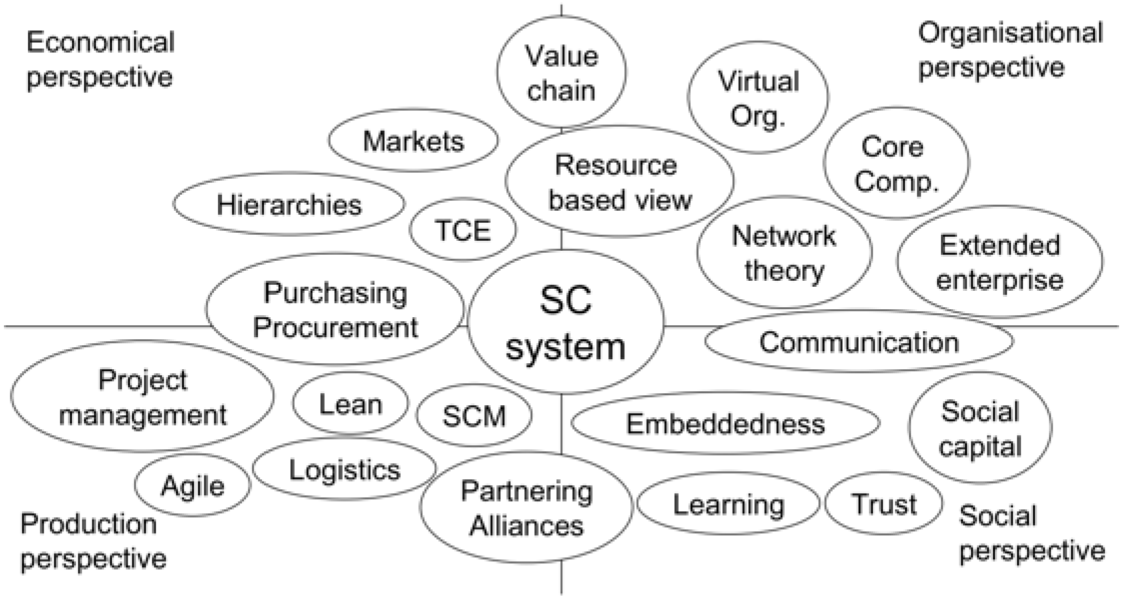

Figure 2-11 The supply chain as a systems engineering theoretical framework (Vrijhoef and de Ridder, 2007)

It can be concluded that AVMs and their stakeholders must work hard to ensure adequate integration, cooperation and collaboration which requires close interactions. The NDS can play a significant role in this aspect. Moreover, AVMs in the Gulf States need, more than others, reliable network with credible providers. However, the author believes that the supply chain can be enhanced by improving the main phases: design, production and T&E by adopting the above-mentioned SC strategies that devote collaboration, cooperation and integration. Therefore, the following sections will consider these three phases of the supply chain and the factors that can be used to enhance the supply chain and thus achieve customer satisfaction.

2.5 Design concept

2.5.1 Introduction

Product design can be defined as an approach that utilises all available and new technology to translate customer preferences into a real product that creates a competitive edge because the value of the product closely matches the customer's needs (Kalyanaram and Krishnan, 1997). Product design phase is important for a developer because it enhances the competitive advantages of the enterprise and improves customer satisfaction. The significance of the product design phase for success is widely acknowledged (Homburg, Schwemmle and Kuehnl, 2015) especially when it becomes synchronised with appropriate supply chain strategies (Haug, 2012). Product design never achieves its ultimate objectives without the appropriate participation of essential players in a network (SC), such as customers, subsystem suppliers, workers on the production line, and external entities such R&D and T&E institutes. The need for such interactions increases as the designed system becomes more complex. A complex product usually has a large number of components and interactions, and its systems behaviour varies over time. In designing a complex product, multiple steps of refinement are required (Li *et al.*, 2013) with appropriate knowledge integration (Haug, 2012; Jayaram and Pathak, 2012).

It is widely believed, both from the above literature review selection and by the author of this thesis, that part of the design process' success is the well-planned involvement of all essential stakeholders. Figure 2-10 shows the relationships that must be established to end up with a suitable product design. In this part of the thesis, the author will show the impact of customer involvement in the product design phase by breaking down all possible obstacles that will face the design team and describing the potential benefits of a customer relationship. Subsystem suppliers also play a key role by improving the product features and increasing the level of integration between add-on components. In addition, R&D institutes (as an essential part of the stakeholders) can contribute by relaying national needs and values. Nevertheless, the involvement of the customer is the most important relationship.

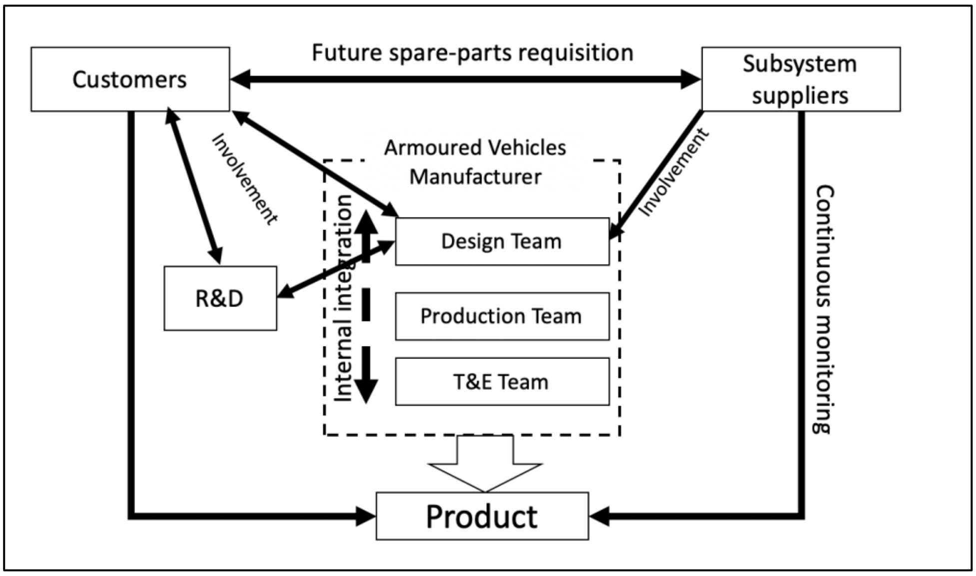

Figure 2-10. The relationship between major parties during the design phase (Author).

2.5.2 Design contribution to the overall development process

The design phase can contribute to the development process by involving all the main players, thus controlling the lead time. Scheduling determines when production will become effective, which means producing a desired result on time with efficient resource exploitation (Nayak, 2011). For example, the lead time can be decided up front during the design phase and controlled by optimised scheduling, redesigning the manufacturing process and using performance systems that allow the enterprise management to make value-maximising trade-offs between lead time and costs (Abdallah and Matsui, 2009). The effectiveness of development must be complemented by efficiency (Berhe, Abebe and Azene, 2015; Eigbe, Sauser and Felder, 2015) to capture customer satisfaction. For example, if a customer requests the early delivery of a product (high effectiveness), more development resources will be dedicated to fulfilling the order in a shorter timeframe, thus affecting production efficiency. Therefore, a tight plan, including a clear timeframe, is more likely to improve customer satisfaction. Indeed, the lead time is crucial for deciding when to deliver a product. Indeed, "*the real challenge for manufacturers has been how to maintain low operational cost and short lead times in a high demand uncertainty environment.*" (Abdallah and Matsui, 2009). Lead time is a measure for deploying the needed value to customers in a shorter time and at a competitive price (Everton Drohomeretskia, b*, Sergio E. Gouvea da Costaa, c, Edson Pinheiro de Limaa, 2014). The author believes that the design phase should involve the determination of the manufacturing process, the T&E process and the resources to be used in the entire development process to understand the development lead time and overall costs earlier, as crucial dimensions for estimating customer satisfaction. Moreover, selecting a reliable supplier eliminates lead time variability.

In this context Hopp *et al.* (1990) suggest some methods that can be used to control lead times such as minimising the inventory to a level where the parts can be obtained as and when needed. Other methods could be keeping the production line moving through tight scheduling, synchronising the production of different functions in a systematic manner, creating a smooth workflow by balancing the work load, eliminating variability by reducing reworks, improving machine reliability, planning correctly for yield losses, and reducing vendor variability, and planning the inventory in such a way that parts requested from far away can be manufactured upon request. Kumar *et al.* (2009) suggest using "*product families and platform-based product development*" to reduce the lead time and cost. They referred to the product family as "*a set of products that have been derived from a common product platform to satisfy a variety of market niches*". These efforts are never made correctly without designing the development process in an earlier phase, i.e. the design phase, with the sufficient involvement of individuals specialising in different functionalities, such as productivity and T&E. Furthermore, the author thinks that individuals are more passionate about performing their tasks if they express their opinions during the design phase.

2.5.3 Customer involvement during the design phase

Liao and Kuo (2014) declared that customer integration helps enterprises to build strong relationships between the internal and external entities of the supply chain network with potential customers and main subsystem suppliers, adding significant value to the organisation and thus increasing its innovation capabilities and competitiveness. Such integration should be enforced by the appropriate involvement of potential parties. Customer involvement is the key to successful interaction because customer satisfaction is increased by the experience and knowledge, which are generated by involvement (Dalla Pozza, 2013). Customer involvement in the design phase increases their satisfaction (Heidenreich *et al.*, 2014). Heidenreich *et al.* (2014) emphasised that participation should be organised well to enhance its outcomes. “*Project managers must plan and choose between the various sources of expertise needed in the design process*” (Couix, Darses and De-La-Garza, 2012). The process of customer involvement can be defined as follows (Menguc, Auh and Yannopoulos, 2014): *"customer involvement in design is defined as activities where customers participate in firm-initiated practices that result in customers providing feedback, information, and knowledge to firms about how to improve design*". They added that the process of customer involvement challenges the customer to consider new ideas generated by the design team. Customer involvement enhances the designer’s understanding of the customer’s real needs (Chen and Sackett, 2009). The author confirms that military individuals have brilliant ideas that cannot be ignored by developers (AVMs), enhancing innovation within the enterprise and customer satisfaction. However, these advantages encourage all stakeholders to participate and add more values, each in their competence, to the developing process by planned involvement to optimise their participations. The following sections are dedicated to undertaking some prime issues, such as the involvement of stakeholders and product definition process, that improve the development process during the design phase.

One major customer involvement issue is the need to enhance the contribution of customers, and other stakeholders as well, during the design phase with innovative ideas. Customers’ involvement has a goal, which is “*listening to customers feedback and solve their problems*” (Chang, Wong and Fang, 2014). In fact, customer involvement can “*improve the quality of design by providing product designers with valuable information about user requirements*” (Menguc, Auh and Yannopoulos, 2014). However, Menguc *et al.* (2014) argue that customer involvement in radical innovation (new products) may harm the developed product while it is beneficial for incremental innovation (updating products).

Customer involvement ranges from being “*information resources and customer participation*” (Laage-Hellman, Lind and Perna, 2014). In this regard, Desouza *et al.* (2008) describe three types of involvement based on innovation types and their attributes as shown in Table 2-7. The first type is the customer-focused innovation (closed innovation and low involvement) in which customers are involved indirectly in the development process for part of the production line. Next level is the customer-centred innovation (open innovation and medium involvement) where customers are allowed to openly participate across all product development steps, as determined by the developer. The last level of involvement is the customer-driven innovation (unstructured innovation and high involvement) in which customers are involved at any time and offer ideas as needed, which help to address dynamic customer needs. Nevertheless, the success of customer involvement depends on the enterprise culture and to what extent do their management accept external ideas (Katsikis, Lang and Debreczeny, 2016)

Accordingly, it has been recognised that developers (AVMs) may adopt customer-centred innovation or customer-driven innovation to ensure the highest levels of

	Customer-Driven Innovation	Customer-Cantered Innovation	Customer-Focused Innovation
Central entity	Customer	Customer and Organisation	Organisation
Degree of customer involvement	Innovation by customers	Innovation with customers	Innovation for customers
Rule of organization	Coordinator	Communicator	Innovator
Type of innovation	Dynamic innovation	Open innovation	Closed innovation
Degree of control	Impossible to control	Difficult to control	Easy to control
Degree of coordination	Emergent coordination	Difficult to coordinate	Easy to coordinate
Critical innovation stage	Commercialisation (Ideas are over-generated and developed, but difficult to commercialize)	Idea development (Ideas are abundant, but difficult to develop)	Idea generation (Ideas are scarce)
Types of innovation to focus on	Products and services, output interaction; interaction with products and services	Communication with customers: customer interaction with organisation	Customer segmentation and customer analysis
Critical issues with innovation types	"Sticky" and tacit knowledge transfer requires high levels of human interaction	Investment in infrastructure	Analysis must be ongoing
	Customers must be segmented for proper analysis	High-quality communication needed	Systems must be integrated
		Risk of copycats	Information overload possible

Table 2-7. Three types of innovation with customer involvement (Desouza et al., 2008)

customer satisfaction. These two types of involvement can enhance new product development at three levels to ensure its success: operational, financial, and marketing (Chang and Taylor, 2016). The author of this thesis' experience shows that the success of new product development can be determined by the ability of the product to operate according to customer requirements (operational), its affordability (financial) and its positive impact on customer satisfaction and loyalty (marketing). Therefore, customer involvement, especially customer-driven innovation, is more beneficial during the ideation stage, during which customers contribute ideas that explain their latent needs and thus reduce anticipated risks (Chang and Taylor, 2016).

It can be determined that maximum involvement at this stage is beneficial for the design team and it is important for military individuals to openly express their needs. Nevertheless, Chang and Taylor (2016) admitted that some circumstances hinder customer participation in innovation, such as limited customer knowledge (in the case of military users), the difficulty associated with managing customer involvement, and the conflict of interest between the provider's management and customers, especially when released information conflicts with customer security precautions. Although the author of this thesis believes that all of the advantages mentioned above are real, he declares that the issues mentioned by Chang and Taylor (2016) are crucial and may degrade the entire design phase.

According to Biazzo (2009), developers must acquire the following abilities to respond to customer needs more effectively. Firstly, they must have the ability to receive and analyse information related to the evolution of customers' needs and the ability to create the most appropriate design that fulfils these needs. Secondly, the design teams must have the ability to experiment and explore product designs to solve customer problems. This ability is generated by continuous learning based on a relationship with the customer. Thirdly, there must be an adequate integration of organisational and technological aspects within the developer's enterprise for the development of a product. Fourthly, the efficient use of expertise related to various skills in design choices. This issue highlights the importance of involving the production-line technicians and T&E personnel in the design phase. Lastly, the ability to build a pilot product that represents the performance of the intended product. The pilot product is needed for testing before initiating mass production. The pilot product can reflect the features requested by the customer, which contributes to their satisfaction. It can be recognised that these five points highlight the essentials of having all related stakeholders in the design phase. The most important one is the subsystem providers besides customers. However, all of these efforts should be underlined early during the business strategy preparation which literally connects enterprise business strategies and their elements to the design phase, which depends on constantly scanning both the external (changes in customer needs) and internal (capability of design team) environments.

2.5.4 Subsystem providers involvement during the design phase

Another substantial involvement is the involvement of subsystem providers during the design phase is important (Menguc, Auh and Yannopoulos, 2014). Brown (2008) states that "*when the design team brings together all the various stakeholders of a company, they are often able to win the commitments from multiple divisions of the company to see new ideas through to production"*. According to the author's investigations, this involvement is negligible in most enterprises (AVMs) even though these developers depend on subsystem suppliers to produce high-quality and trusted protection vehicles. However, in the context of increased reliance on innovation and product development as a means to achieve competitive advantage, it is valuable for many providers to integrate subsystem suppliers more extensively into their new product development process (Lawson, Krause and Potter, 2015). Indeed, the involvement of subsystem suppliers has a positive effect across a range of performance outcomes, including reduced material costs, improved material quality, shorter development times, lower project costs, enhanced product functionality, improved product manufacturability, lower manufacturing costs, and access to supplier technology (Lawson, Krause and Potter, 2015). Furthermore, developers may use the insight and technological skills of subsystem suppliers to create superior value, and gain a competitive advantage in product design and other aspects of new products. The involvement of subsystem suppliers in design varies from providing design information to assuming responsibility for the design of the components, systems, and processes, all of which result in better designs (Menguc, Auh and Yannopoulos, 2014). To summarise, AVMs, as developers, must integrate with the subsystem providers, especially when the developed product is new.

2.5.5 Product definition and customer satisfaction

Product definition plays a significant role in determining customer satisfaction because military customers have a certain image in mind and they want to see it in the field regardless of potential technical and financial limitations. Based on the author's experiences, developers like AVMs often cannot fulfil all customer needs because there is a weak relationship between the design team and customers. Therefore, the author raises this issue to highlight the most important factor that influences customer satisfaction: the product's definition (ergonomics). "Ergonomics plays a vital role in the analysis of users' needs. Needs analysis is an essential step in a design project" (Couix, Darses and De-La-Garza, 2012). Couix *et al.* (2012) add that ergonomics is not a stand-alone subject, but needs to be supported by other disciplines such as system engineering. A given design often includes definitions which cannot be included in one paragraph, but there are three main dimensions: aesthetics, functionality, and symbolism. All product characteristics can be assigned to these dimensions to different extents, as shown in Table 2-8 (Homburg, Schwemmle and Kuehnl, 2015).

Dimension	Customer Quotation
Aesthetic dimension	• "I think the design is more beautiful." • "I find this somehow more appealing. It seems somehow wider and rounder. This one is more massive. That one is a little more elegant." • "When I imagine having this one in the kitchen, it would truly be an eye-catcher." • "I prefer this … because of its design: It's just more striking."
Functional dimension	• "The features are pretty important to me. I don't need a camera that is super good but I want a strong Wi-Fi connection." • "It seems to be well made and sturdy … and probably is also Wi-Fi and even LTE-enabled." • "It is light and practical." • "Falling toy blocks don't cause any scratches or defects. This table is made of a special, hardened glass."
Symbolic dimension	• "When you want to portray something to the outside world, you always want to show that you have good taste, that you value yourself sufficiently to allow yourself some luxuries such as a fancy phone. You portray parts of your lifestyle." • "If a person really cares about how a product is designed, then maybe this could imply something about that person. However, if the person does not care then there is nothing that can be implied about him or her." • "I think that many people define themselves through, for example, their smartphones." • "It's elegant and streamlined. And it doesn't have the image of a show-off car … or a granny car."

Table 2-8. Three-dimension model of design (Homburg, Schwemmle and Kuehnl, 2015)

The aesthetic dimension refers to the perceived appearance and beauty of a product (Campbell *et al.*, 2007). For example, military customers usually claim that the inside of the vehicle's shape is uncomfortable for soldiers to stay in for hours but most AVMs do not care about internal appearance. The functionality dimension reflects the consumer's perceptions of a product's ability to fulfil its purpose (Homburg, Schwemmle and Kuehnl, 2015). For example, the designer might overlook the environmental impact on the vehicle's performance, especially high temperatures and sand. The vehicle's engine temperature, during the summer, might increase far enough to disable the vehicle in a critical situation that reduces the vehicle's reliability. The brake system elements might not be designed and selected to work in a hot environment, leading to damage that affects other systems. The brake fluid might also be affected by hot environments, if the correct grade is not selected. Finally, the symbolic dimension refers to the perceived message that a product communicates in terms of the consumer’s self-image and appearance to others on the basis of visual elements (Homburg, Schwemmle and Kuehnl, 2015) . From the author’s experience, military users sometimes refuse to accept vehicles because the hood shape does not appear intimidating enough to be used for military purposes. Such crucial issues must be discussed with the customer during the early development phase to avoid further costs related to extended product amendments. It has been observed that ignoring one of these dimensions during the design process will lead to there being interruptions later during the production or T&E process. The results would be more rework associated with increased costs and lead time and decreased customer satisfaction.

"*The engineering design process starts with a design problem expressed as a need (i.e. customer or initial requirements) that must be satisfied by the creation of a physical product or system*. *These needs provide the foundation for engineering design efforts but do not necessarily provide all the knowledge required for the subsequent design process and should thus be analysed*” (Brace and Cheutet, 2012). Moreover, Creusen (2011) lists some of the requirements that design teams should adopt to deal with customer needs efficiently. Firstly, he insists on understanding the customer needs by using different contemporary tools and methods. Secondly, designers may work closely with the market researcher. Thirdly, the design process should be wisely managed to increase its efficiency. It is concluded that the design phase is a critical stage in the overall development process and must be performed correctly based on predefined polices.

2.5.6 Quality of the product and customer satisfaction

The quality of a product is the backbone of customer satisfaction (Hendry Raharjo, 2007), especially when one relates it to a soldier’s life, because it reflects the customer’s overall evaluation of the product. However, quality criteria differ according to the product type. The distinctive attributes of a product can enhance its quality and distinguish enterprises from their nearest competitors, thus increasing the competitive value (Lai *et al.*, 2008). Moreover, the customer and the developer work together to produce the best product for both in terms of quality and price, which increases customer satisfaction (Dongmo and Onojaefe, 2013). Product quality can be defined as “*product features matched with eight dimensions, namely:*

performance, features, conformance, reliability, durability, serviceability, aesthetics, and customer-perceived quality" (Shaharudin *et al.*, 2012). This definition shows that product quality is simply a combination of the standard operational features and design attributes which must be comprehensively included during the design process which must also be in quality condition. Based on what Lai *et al.*(2008), Dongmo and Onojaefe (2013) and Shaharudin *et al.* (2012) stated, the author of this thesis confirms the link between good product design and the quality of its features.

According to the author's investigations, most AVMs, particularly in the Gulf States, are proud to acquire ISO certificate as an indication of their quality. However, ISO may deceive customers and have negative consequences if customers fail to

Total quality management (TQM)	Six sigma	Lean
Customer oriented	Aims for zero defects	Aims to eliminate waste
Improves process	Reduces variations	Improves process flow
Increases customer satisfaction	Saves resources	Reduces lead time

Table 2-9. Similarities and differences between total quality management, six-sigma and lean management (Andersson, Eriksson and Torstensson, 2006)

recognise real quality during operations. The fact that "*Customer satisfaction and process improvement have been found to be the main reason for ISO 9001 implementation by most companies*" (Dongmo and Onojaefe, 2013) might deceive the customer. The quality is not the ISO. The proven quality and reliability of the Japanese automotive industry has led the trend towards using higher quality tools, such as total quality management (TQM), six sigma, and lean management. The use of six sigma/lean management by enterprises has increased dramatically over the last few decades, driven by their requirement to produce high-quality products using a quality process in order to fully satisfy their customers and sustain their business in a competitive market by earning profit while gaining the edge over competitors. Although all quality practices are similar in their aim to enhance product quality, each concept has its own approach. The similarities and differences are summarised in Table 2-9 (Andersson, Eriksson and Torstensson, 2006).

"*Total Quality Management (TQM) and business excellence have become major elements in the business strategy of many companies. Improvement in quality shows the way to increases in stakeholder satisfaction, profitability, market share and decreases in manufacturing costs, as well as promoting company competitiveness.*"

(Rahman and Tannock, 2005). All stakeholders, not only the developer, benefit from adopting TQM (García-Bernal, J., & Ramírez-Alesón, 2015) since it aims to improve the development process through the appropriate involvement of potential parties. Lean, on the other side, aims to reduce waste by "*using less of everything*" by everyone (Anvari, Ismail and Hojjat, 2011). "*Six-sigma is applied to achieve high quality results, achieve customer requirements and satisfaction, reduce defects in the implementation, and ensure that quality levels are maintained*" (Sareen, Laux and Marshall, 2014). "*Six-sigma is an organisational learning process and one that results in greater knowledge"* (Gutierrez, Bustinza and Molina, 2012). These definitions of the three managerial methods are essential for having a quality process and product. Each practice cannot stand alone if the management aims to lead their enterprises to definite success. Therefore, "*An integrated approach to process improvement using lean manufacturing and six-sigma principles is required since both lean manufacturing and six-sigma are more of a cultural change meant to be the way a company does business rather than a one-time tool to be used for quick improvement*" (Cudney, Mehta and Monroe, 2006). Based on what is stated above, the author asserts that ignoring quality tools means that one would degrade one or all of these aims: improving the process, reducing the variation and/or improving the process flow. This degrading affects both the enterprise performance and customer satisfaction.

Many practitioners have advised enterprises to apply quality principles at the early stage of the product development process i.e. design phase. Different sources in the literature have attributed this vital movement to Taguchi, who asserted that it is easier to design a product that can perform over a wide range of environmental conditions if the associated production process can detect defects before deployment (Besterfield, 1999). Taguchi was likewise the first to believe that manufacturers should focus on design quality rather than defect repairing when developing a process. Besterfield (1999) has also stated that the earlier defects are found, the less costly they are to correct Figure 2-11. According to Taguchi and Besterfield, it is essential to initiate the development process, during the design phase, with appropriate quality tools such as six sigma and DFSS, as will be discussed in the next section.

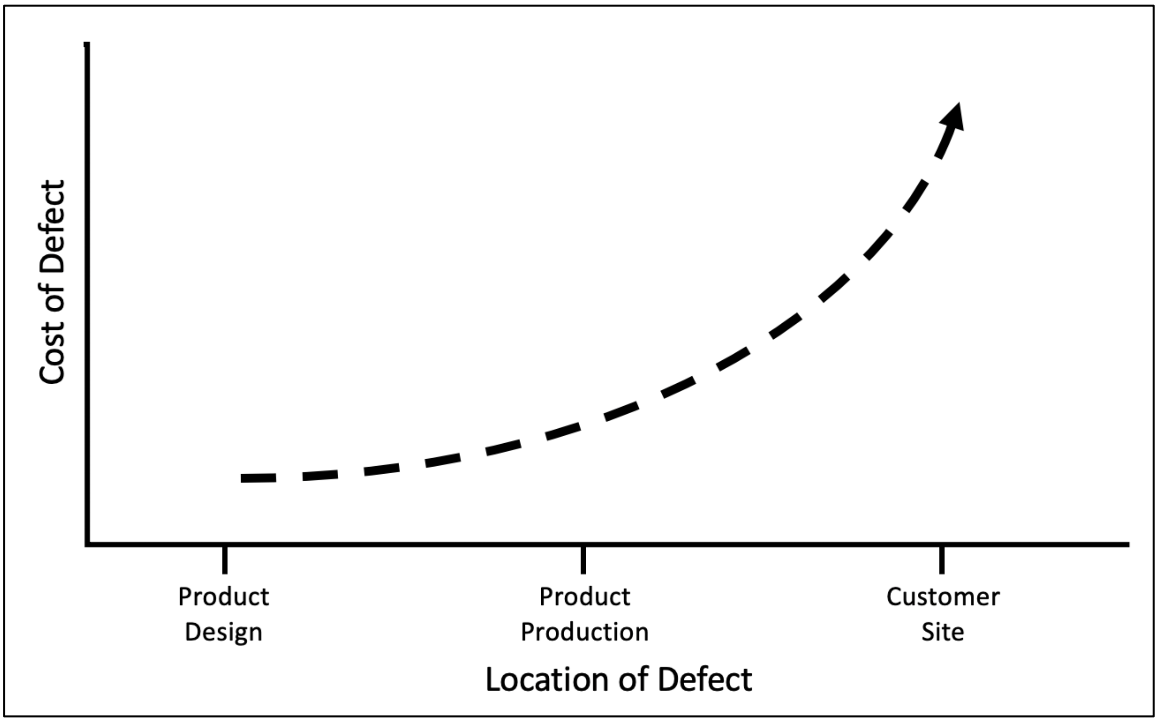

Figure 2-11. Cost of defects (Besterfield, 1999).

2.5.6.1 Design with quality tools: Six sigma and DFSS

Six sigma helps enterprises to improve their operations, enhance quality, eliminate defects, and thus capture customer satisfaction (Raghunath and Jayathirtha, 2014). Moreover, to emphasise the design phase, developers that used to apply six sigma have departed from the traditional "*define, measure, analyse, improve, control*" (DMAIC) approach, where improvements occur later in the process, towards a more design-oriented 'Design for Six Sigma' (DFSS) approach (Watson and DeYong, 2010). Indeed, applying DFSS as a customer-oriented tool to the existing design process can enhance customer satisfaction by improving the quality, reducing the lead times and/or reducing the production costs (Rafique, 2013). Raghunath and Jayathirtha and Rafique pave the way for managers to apply the DFSS to improve their next development process. Although DMAIC has been used successfully to reduce process variations and cost (Smith, 2016), DFSS places particular stress on the development of robust designs that avoid defects at an early stage, thus preventing situations where such defects become apparent later during the manufacturing process (Tien, Chung and Tsai, 2005). In fact, the DMAIC tool has extended the use of six-sigma to cover many fields "*like medicine, software, billing, purchasing etc.*" (Sareen, Laux and Marshall, 2014). "*DFSS supports management* *of design programs in the product creation process'* (Watson and DeYong, 2010). De Feo *et al.* (De Feo and Bar-El, 2002) highlight the ability of DFSS to reduce the lead time and cost compared with traditional design methods, primarily because it is more customer-oriented than DMAIC, but also because it can predict design quality at an early stage, integrate cross-functional design involvement, and monitor process variances earlier to verify that the customer requirements are met. The latter definition explains how the DFSS process helps achieve customer satisfaction while reducing production costs, which have multi-directional effects on all stakeholders, customers in particular. It is obvious that planning to reduce defects in the earlier stages by using DFSS is a crucial approach to shorten the lead time and minimise the development cost where customer satisfaction can be certainly achieved.

To replicate the special application of DFSS, designers may follow different approaches with similar procedures. To this end, researchers have proposed a variety of DFSS models, including DMADV, IDDOV, DMEDI (Azis and Osada, 2013), IDOV, DMADOV and CDOV (Yoon and Byun, 2012). However, the mostly widely-used DFSS applications are DMADV (define, measure, analyse, design, verify), IDOV (identify, design, optimise, validate) and DCCDI (define, customer, concept, design, implementation) (Thomas, 2013). To clarify the concept of the DFSS models, the most popular DFSS application process (DMADV) is defined by Pendokhare and Quazi (2015). The first stage is called the 'define' (D) stage which is used to establish the need, shape the team with objectives to design a value that fulfils the need, define the development stages with an intermediate target to be clear for all stakeholders, and identify potential risks. According to DFSS, the process is initiated by simply collecting data through market research, the voice of the customer (VOC), and interviews (Montelisciani *et al.*, 2014). The second stage is the 'measure' (M) stage where data is gathered and analysed to measure each stage's performance precisely and list any emerging problems that hinder the development process. The data at this stage include both the quality of the development process through critical to quality (CTQ) attributes, and critiques of the product features through quality function deployment (QFD) attributes. Next is the 'analyse' (A) stage in which all alternatives are compared to decide on the best conceptual design that approaches customer and market needs. The fourth stage is the 'design' (D) stage, which brings together the best product features and corresponding manufacturing process together. This includes critical process parameters, failure analysis, capability analysis, and statistical analysis to determine acceptable tolerances. For example, a robust design analysis is a technique that reduces any variation resulting from internal noise (due to machine wear and tear) or external noise (due to changes in the manufacturing environment) (Arvidsson *et al.*, 2005). Last is to verify (V) where some stakeholders, especially end-users, verify the developed values by pilot testing, before mass production is initiated. This stage includes selecting the best method to deliver the value to the end-user and related procedures. The design team can use a Kano model, for example, to test the overall satisfaction of their customers (Hendry Raharjo, 2007). The author introduced different tools that belong to six-sigma and TQM that have been used in the design process and led to adequate results, according to the above-mentioned scholars.

In line with the wide variety of DFSS approaches, there is an inherent uncertainty in a design team selecting the best methodology (Yoon and Byun, 2012). The design team can thus adopt a comprehensive SE model from concept to validation, such as PADOV. Figure 2-12 shows how PADOV can replace DFSS roadmaps and yet still comply with the six sigma concepts, and Figure 2-13 shows that all of the DFSS tools are typically applicable in each phase of PADOV. The five phases of DFSS-PADOV listed above are all important in leading to a comprehensive and efficient product that enhances stakeholder satisfaction, particularly the customers.

Phase	Plan, technical effort (**P**)	Analyze requirements (**A**)	Define, candidate architecture (**D**)	Optimize and evaluate alternatives (**O**)	Verify, the system (**V**)
DFSS tool	3C SWOT Strategic plan MGPP WBS PERT/Gantt chart Project charter	Interviews Market research VOC Affinity diagram Quality history Kano model Benchmarking QFD	Brainstorming FAST Block diagram Morphological box TRIZ Axiomatic design QFD Pugh matrix P-diagram FMEA DOE CAD/CAE	Statistical tolerancing Design for manufacture/ assembly Robust design development Multi-disciplinary Design pptimization Sensitivity analysis Simulation DOE	Prototyping Mistake proofing Process capability assessment Design verification plan and report Robustness/ reliability demonstration Gap analysis Control plan

3C: customer, competitor, company, SWOT: strength, weakness, opportunity, threat, MGPP: multi generational product planning, WBS: work breakdown structure, VOC: voice of customer, QFD: quality function deployment, FAST: function analysis system technique, TRIZ: theory of inventive problem solving, FMEA: failure modes and effects analysis, DOE: design of experiment, CAD/CAE: computer aided design/computer aided engineering.

Figure 2-12. PADOV as a replacement for DFSS (Yoon and Byun, 2012)

Phase	Plan, technical effort (P)	Analyse Requir-ments (A)	Define, candidate architecture (D)	Optimise & evaluate alternatives (O)	Verify, the system (V)
DMADV	D	M	A	D	V
DMADOV	D	M	A	D&O	V
IDOV	I	I	D	D&O	V
DMEDI	D	M	E	D	I
DCCDI	D	M	E	D	D&I
IDDOV	I	D	D	O	V
DCOV	D	D	C	O	V
CDOV	C	C	D	O	V

DMADV: define, measure, analyse, design, verify. **DMADOV:** define, measure, analyse, design, optimise, verify. **IDOV:** identify, design, optimise, validate. **DMEDI:** define, measure, explore, design, implement. **DCCDI:** define, customer, concept, design, implement. **IDDOV:** identify, define, develop, optimise, verify. **DCOV:** define, characterise, optimise, verify. **CDOV:** concept, design, optimise, verify.

Figure 2-13. DFSS tools in PADOV (Yoon and Byun, 2012)

2.5.7 System Engineering in Design Process

Many enterprises use repetitive SE models and standards in their daily practices, illustrating the sequence and interactions among the necessary activities for system development (Guey-Shin Chang, Horng-Linn Perng, 2008). System of systems (SoS) is a branch of SE used for systems design, comprising a system that consists of many subsystems that overcome factors in the dynamic environment that may affect the system during the development process and everything that precedes this (Dahmann and Baldwin, 2011). SE can enhance the design phase by: understanding the system requirements, defining the system architecture, designing the system and tracing its evolution in accordance with changes in the operational environment, and system verification. These models include the waterfall model, spiral process model of the developmental life cycle, and the Vee process model (will be discussed later). Such models are essential for discovering and remedying problems, in an iterative manner, any unpredictable deficiencies that lead to system failure (Thomas, 2007). Moreover, the design phase contributes to the success of the entire system which includes all stakeholders (subsystem) with appropriate integration (Boehm *et al.*, 2012). Therefore, it is important for the enterprise management to consider adopting such beneficial tools to fulfil the integration among their enterprise's stakeholders and develop such values that satisfy their customers. In addition, the SoS can play a significant role in combining all stakeholders into a network to fulfil a goal by sharing their efforts through well-planned involvement. As discussed earlier, different types of involvement are required to enhance the design process, as well as other development processes.

2.5.8 Summary

The design phase is significant in the creation of a robust supply chain for many reasons. First, it encourages the involvement of essential bodies and enhances communication among them. For example, the design process (1) brings the customer to meet the designer, (2) communicates with subsystem suppliers to enhance product attributes, and (3) seeks the contribution of production functionalities to design the production process. Moreover, the design phase ensures (1) all needs are included in the product with sufficient innovation, and (2) the quality is implanted within the product in during early development. However, these aspects should be part of the NDS and enterprise business strategy to ensure customer satisfaction. Figure 2-14 shows the role of the design concept in enhancing customer satisfaction within the guidelines of the NDS and business strategy. The next section discusses productivity as an execution of the design and as another essential component of a robust supply chain.

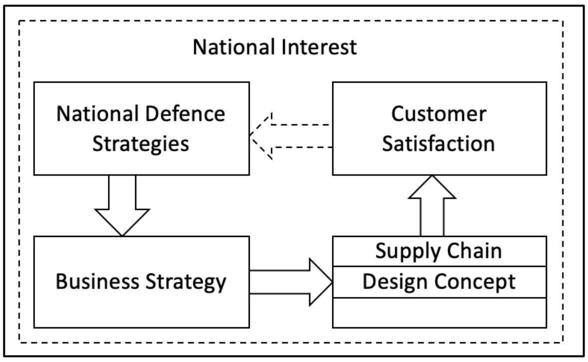

Figure 2-14. The impact of the design concept on customer satisfaction (Author).

2.6 Production and productivity

2.6.1 Definition of productivity

AVMs in the Gulf States face tremendous risks, which must be addressed by the management. The anticipated production waste is one of these risks, but it can be controlled and minimised to reduce both production costs and the lead time, ensuring customer satisfaction. Production waste reduction relates directly to higher productivity, which can be defined as a measurement of efficiency where the output is compared to the input (Anderson, Fornell and T. Rust, 1997) and the difference (percentage) between them is the waste (Aparicio *et al.*, 2016). The author has recognised[5] that it is difficult to apply this formula in practice, especially when one visits an AVM workshop and sees some vehicles undergoing work and others waiting for a technician or a part. It is necessary for the shop manager to recognise delays and attempt to prevent waste. It may be impossible to include all waste in a formula in order to determine productivity precisely (Berhe, Abebe and Azene, 2015). This has a great impact on the estimation of costs, and thus affects market prices and (ultimately) customer satisfaction. Waste may occur in "*inventory, motion, transportation, rework, over/under-processing, and downtime*" with the last three types needing most attention (Berhe, Abebe and Azene, 2015). The author of this thesis considers that earlier productivity estimations have not measured these types of waste precisely, and they are discussed in more detail below.

2.6.2 Productivity problem in the AVMs in the Gulf States

The author recognised that downtime waste is one of the most disruptive factors affecting an enterprise's productivity, as confirmed by all of the initial interviews with the AVMs in the Gulf States. This is due to fluctuating demand, especially for local enterprises, which depend on local or regional demands. The AVMs, through the initial interviews, claim that, during idle time, technicians' wages and indirect costs must still be paid, meaning that the total costs increase and must be distributed equally across upcoming projects, thus affecting future productivity. The productivity of each project is therefore difficult to calculate, prices are overestimated, and satisfaction declines.

The author also considers scrap/reworking as another factor that must be addressed by AVM managements, especially when customers are involved at a later point in the development process. Late customer interactions will identify unwanted features (from the customer's perspective) which are already in the final design, and any alteration, removal, or addition will lead to higher costs compared to the same changes at an earlier stage. These costs can be high, especially if it involves the removal or alteration of armoured plates. The author believes that reworks is a factor that contributes to increasing the lead time as well as costs which in turn reduce the overall customer satisfaction, especially for military customers that are particularly

[5] During the shop-floor visits and asking management about calculating productivity.

sensitive to costs and time. Enterprises may also face the problem of over production (under) production, which can be defined as "*making more (less) than is required by the next process or customer*" (Berhe, Abebe and Azene, 2015). Underproduction might follow the situation described above as downtime waste, so this section focuses instead on overproduction.

2.6.3 Enhancing Productivity

Enterprises must therefore enhance their productivity and reduce costs, especially in fiercely competitive dynamic environments. Indeed, the dynamic competitive market forces enterprises to continue monitoring their productivity and using their resources wisely (Funakoshi and Motohashi, 2009). Enterprises can also increase their productivity through process innovation based on three strands (Mañez *et al.*, 2013): (1) R&D investments in innovation and, thus, elevated productivity; (2) continuous organisational learning; and (3) applying the appropriate innovation to foster productivity. Manez *et al.* (2013) complement Funakoshi and Motohashi's efforts in enhancing productivity through two main processes: continuous learning and applying innovation. Furthermore, Perera (2016) suggests using lean management to reduce waste and improve productivity. So, productivity relies to a high extent on human resources. In the same context, Cooper and Edgett (2008) reveal that there is a remarkable difference in productivity in terms of developing new products among different enterprises in the same industry due to differences in resource management. The author believes that such differences make SMEs (including AVMs) with minimal resources more vulnerable to productivity issues if they fail to deal with input resources wisely and strictly, which could lead to business failure.

The management and their subordinates can play significant roles in enhancing development productivity. For example, the entrepreneurship style of management, with qualified human resources, can help SMEs (including AVMs) to enhance their productivity (Kurniawati and Yuliando, 2015). This is because entrepreneurs can exploit their resources more effectively (Dogan, 2015), which motivates other enterprises to act similarly under intense competition. The road is paved for enterprises to enhance their productivity provided that the recommended tools are used. This will also enhance the organisational learning cycle which in turn provides competitive resources (Ringen, Welo and Oøsterbø, 2016). Cooper and Edgett

(2008) provide some crucial causes for higher productivity such as introducing values that benefit customers, providing better value for money, and producing values that meet the customers' needs. The author of this thesis believes that these motives would not have been obtained without using new technologies in production lines managed by the best practices. These organisational efforts will help to enhance the organisational learning and strengthen the human capability, thus increasing productivity. As mentioned by many scholars, these interests must be supported by entrepreneurship leadership, process innovation, and planned learning cycles that enable enterprises gradually to enhance their internal resources to cope with the available technologies that help in increasing productivity.

The conclusions of the empirical study of Mañez *et al.* (2013) has indicated that the process innovation, which is designed to enhance productivity, has a significant effect on the competitive position of SMEs, and the key terms for better productivity in SMEs are therefore innovative processes, entrepreneurial practice, and learning.

2.6.4 Innovation and technology to enhance productivity

Chavez *et al.* (2017) declared that innovativeness is related to a number of actions: Firstly, *"opportunity-seeking behaviour, characterised by the introduction of new products/services ahead of the competition in anticipation of future demand".* Secondly, *"taking bold actions and committing important resources to ventures in uncertain environments".* Thirdly, *"it encourages customer involvement within the innovation process, especially through the co-creation of values, embrace continuous innovation*". They add that this definition is aligned with the entrepreneurship orientation: "*innovation is the development of new values through more efficient and effective products and processes*" (Hsu *et al.*, 2014). According to Chavez *et al.* (2017) and Hsu *et al.*(2014), innovation requires new processes to be implemented that enhance productivity and reduce waste which influences customer satisfaction; these new processes may be called technology and/or know-how. In this regard, Capon and Glazer (1987) defined technology as "*the information required to produce and sell a product or service*", and referred to the "*know-how*" concept, that can be experienced through three main practices: product technology (the product's features), process technology (the best tool for developing value), and management technology (the best approaches to use organisational resources efficiently and effectively). This definition allows us to understand the impact of technology in certain disciplines in broad terms, such as supply chain management, quality management and operation research enabling enterprises' managements to achieve optimal values in terms of product features at an affordable price. Indeed, product technology (represented by its features), and affordable price (as the consequence of the technology process and management technology), help to ensure customer satisfaction. Moreover, Nedelea and Păun (2009) underline the significant relationship between the enterprise strategy and know-how that enables all concerned resources required to perform their task towards the predetermined goal efficiently and effectively beside enforcing the learning capability within the enterprise, where the creation and sharing of knowledge, as part of the learning cycle, is necessary for product innovation and managing different types of risks resulting from complex environments (Locatelli, Mancini and Ishimwe, 2014). Technology utilisation is associated with the innovative process and output (Weinstein, Jin and Barrett, 2013). They add that such type of process involves "*the identification and sequencing of work activities, tasks, resources, decisions, and responsibilities across time and place, with a beginning and an end, along with clearly identified inputs, transformations, and outputs*" (Weinstein, Jin and Barrett, 2013). The output of the enterprise provides the promised values, but the innovative output must be targeted through the innovative process. Innovation requires sufficient interactions between the provider's individuals, a pro-innovation organisational culture, and a management that believes in creativity and its positive impacts on organisational performance and output (Weinstein, Jin and Barrett, 2013). According to them, creativity and innovation can be therefore linked to entrepreneurship practices, which first possess a pro-innovation climate with risk acceptance, dealing with failure, a good reward system and encouraging collaborative business relationships. Secondly, these practices encourage customer involvement within the innovation process, especially through the co-creation of values. Thirdly, entrepreneurship practices embrace continuous innovation, especially during crises and problems. Fourthly, they accompany innovation with sufficient planning tools, including brainstorming sessions, and face-to-face briefings on technology initiatives. Innovation is always coupled with continuous learning (Taylor and Taylor, 2014). As mentioned earlier, the most appropriate strategies for coping with a dynamic environment are differentiation and cost leadership, where differentiation is strongly linked to innovation and associated with innovation and leadership (Semuel, Siagian and Octavia, 2017).

To acquire a healthy innovative culture, enterprise managements should strive to establish and maintain organisational learning within the enterprise (Huang, Wang and Procedia, 2011). In fact, "*innovation depends on the firm's capability to learn through which new knowledge is developed, distributed and used*."(Kafetzopoulos and Psomas, 2016). This enhances individual knowledge within the organisation, which is considered a potential asset for further innovation. Such a learning orientation depends on two main factors (Huang, Wang and Procedia, 2011): (1) a marketing orientation, and (2) an entrepreneurial orientation. Both directions help enterprises collect necessary information related to the market and their competitors in order to understand their customers' needs in detail. These valuable insights will undoubtedly lead to the creation of new and innovative ideas, but this requires the existence of an innovative culture across internal human resources. However, the author admits that collecting data from military customers is not an easy task, requiring frequent interactions and a strong relationship between the developer and its customers. The primary objective is to satisfy both the customer and market's needs by offering the best value in terms of the surrounding environment. This is achieved by adopting a learning orientation to improve the enterprise's human resources. A learning orientation increases the satisfaction of employees and their commitment towards the organisation (Singh, Leader and Limited, 2016). This encourages them to accept new challenges and create innovative values in form of process and product which, in turn, adds more value to the organisation and its shareholders and achieves customer satisfaction. In summary, a learning orientation, entrepreneurship and innovation establish the necessary human resources and other capital resources to enhance productivity, thus contributing to customer satisfaction.

2.6.5 Summary

Enterprises strive to enhance their productivity by reducing waste (more efficiency) and shortening lead times (more effectiveness), and each dimension significantly affects customer satisfaction (Figure 2-15). Productivity must be addressed at an early stage of product design to ensure a smooth value stream, and this is best achieved by involving the key stakeholders such as customers and subsystem suppliers. Practitioners and scholars recommend practicing entrepreneurship and innovative processes. The production process and product must be assessed and evaluated according to predetermined milestones, which are discussed below.

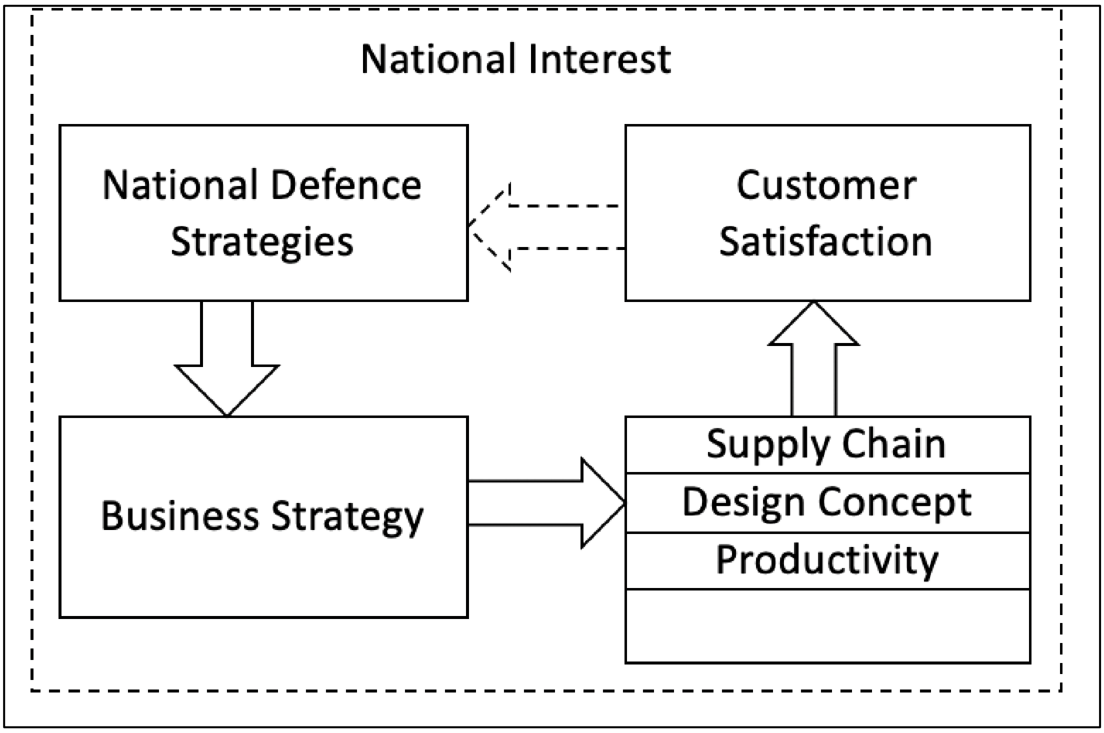

Figure 2-15 the position of productivity in enhancing customer satisfaction (Author)

2.7 Testing and evaluation

According to the Australian Department of Defence (2015), "*T&E is an important tool in our plans for the management of defence capability to ensure successful achievement and maintenance of operational effectiveness*". The UK MOD` (2005) considers that "*T&E is vital to the development, introduction into service and through-life support of the equipment used by our Armed Forces. It contributes to a variety of activities which reduce risk to our Armed Forces. We use a mixture of in-house, Government Owned Contractor Operated (GoCo) and commercial T&E facilities in the UK to support the acquisition and sustainment of military capability*". These two statements provide excellent examples of how defence authorities worldwide appreciate T&E as essential for the validation of developed values to secure their nation. Thus, developers must accept the defence authorities' interests in applying the necessary T&E and understand how to implement T&E to ensure that their products are acceptable to the customers.

The T&E phase is a critical step in the development process because it evaluates both the development process and the product. The purpose of T&E is "*to catch defects early and minimise the cost of fixing defects late in the process, which is influenced by the T&E strategy*" (Eigbe, Sauser and Boardman, 2010). In other words, T&E should ensure that high-quality products are produced within the two main constraints of cost and time, as the prime criteria for capturing customer satisfaction, thus a systematic process is not an option. The T&E process is "*an integral part of the Systems Engineering Process (SEP), which identifies levels of performance and assists the developer in correcting deficiencies. It is a significant element in the decision-making process, providing data that support trade-off analysis, risk reduction, and requirements refinement. Program decisions on system performance maturity and readiness to advance to the next phase of development take into consideration demonstrated performance. The issue of paramount importance to the service member user is system performance; i.e., will it fulfil the mission*" (Defence Acquisition University, 2005). The author, from long dealing with different defence manufacturers, always believes that this phase has not received adequate attention from many providers and their customers.

Sydenham (2004) highlights some practices that can hinder T&E (the author recognised such shortages as well) such as there are no traceable test documents that illustrate the standard tests that must be performed. This provides an opportunity to conduct arbitrary tests which depend on the individual's intentions and may result in different processes being used for similar tests. Moreover, evaluations are not available and decisions are based on random tests. Another drawback is that tests may be set by the designers alone, who face numerous objections later during the final T&E stage. Furthermore, there is a lack of subsystem tests before they are assembled to form the main product. This causes suspicion during the integration of different subsystems until the final test, which may cause result in the detection of late defects that require reworking. Fourthly, SMEs usually neglect essential T&E due to the costs, which affect final market prices and their competitiveness. Lastly, "Last-minute decisions" or no prior determination of test schedules can result in the use of incorrect test procedures, leading to untrustworthy results. Sydenham (2004) argues that to overcome such pitfalls, T&E must be respected as a major and well-organised activity, performed according to precise predetermined milestones to ensure there is sufficient information about the product and production process at all stages

It is necessary to respect the above two definitions – which are mentioned above - that highlight the importance of the T&E process because it supplies vital information related to the product’s functionalities and a production process relevant to all stakeholders, enabling them to make informed decisions. T&E can explore many aspects and dimensions that contribute to the success of product development, especially in new projects. For example, in addition to the prime objective of T&E, which is to investigate product performance, it also examines the level of risk associated with the development process and the level of maturity that the product has reached. This process traces with precision the efficiency and effectiveness of both the product and the associated process, at various stages.

Figure 2-16 summarises the importance of T&E, which covers the entire development process, not only the last step in the process, to examine the technical aspects of the product and it the management decisions and practices which control the development process (Barrett, Hart and Wascavage, 2009). T&E can be defined as two separate functions which are used in sequence (Barrett, Hart and Wascavage, 2009). Testing is a process for capturing data, whereas evaluation is a process for analysing the data. Any given decision creates a new situation which requires another test, followed by an analysis to come to another decision. These decisions may reflect the end of a development process stage or the confirmation of process compliance with predefined standards. These iterative processes (as shown in Figure 2-16) are more efficient and effective if they have involved the major stakeholders. Customer sharing is important, and is controlled and imposed by system acquisition strategies, which are derived from defence strategies in the case of military customers (Barrett, Hart and Wascavage, 2009). The author strongly believes that such beneficial contributions control the cost, lead time, product efficiency and the associated risks.

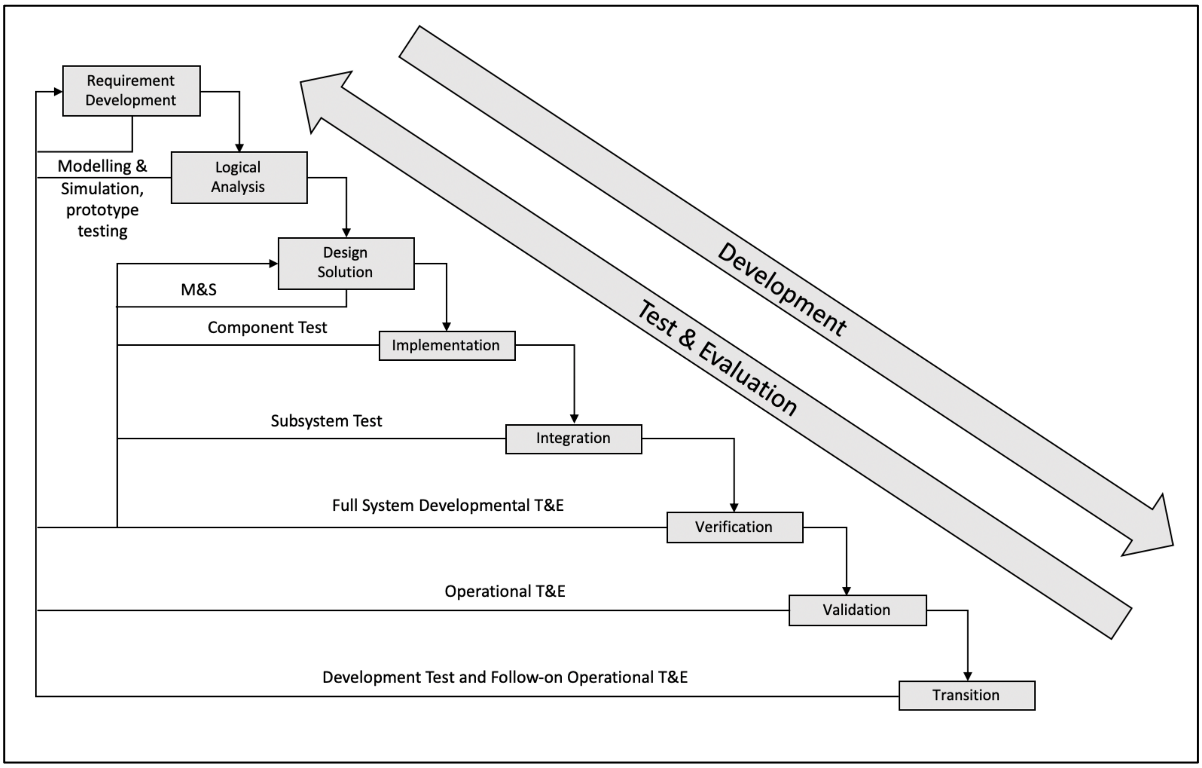

Figure 2-16. Roles of T&E in the system development process (Barrett, Hart and Wascavage, 2009).

The creation of a framework or plan for T&E requires three questions to be addressed (Sydenham, 2004): what is the goal that the system development team is trying to achieve? When they are going to achieve this goal? And finally, who is responsible for achieving the best outcome? According to Sydenham (2004), the answers ensure an effective T&E process in terms of the precise timing of the tests without extra costs, and with no possibility for extra tests that will delay the deployment of the product. The contribution of Sydenham (2004) indicates how managements should organise different T&E activities to include the entire development process and the time frame to inform all involved parties of what, when and how to test based on the roles of Barrett *et al.* (2009) shown in Figure 2-16.

Reynolds (1996) argues that T&E activities might be extended to include the entire

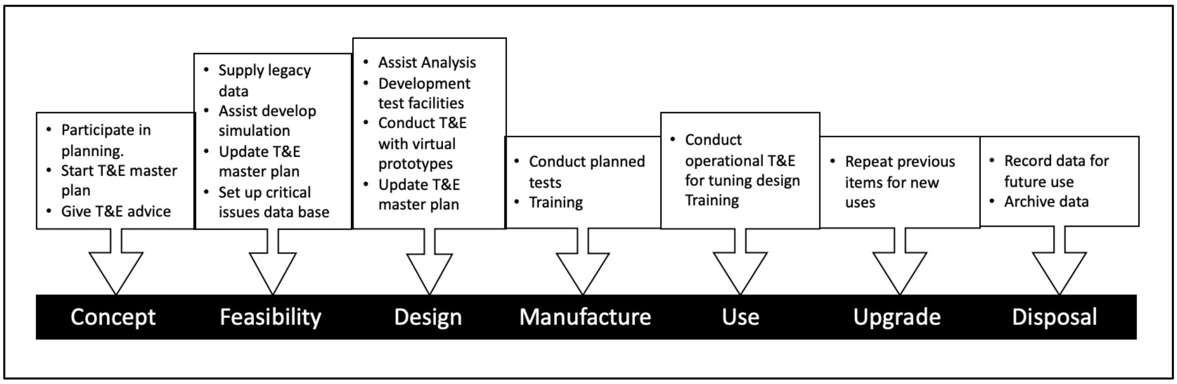

Figure 2-17. T&E throughout the system life-cycle (Reynolds, 1996).

life-cycle of the product, which will undoubtedly enhance product performance as shown in Figure 2-19. This figure illustrates some of the key points related to T&E activities at different stages of the system life-cycle. According to Reynolds, the T&E plan should include: (1) the system's features and technical thresholds; (2) the system's modifications introduced in the latest development; (3) the critical aspects of the system design that affect the program's continuity; (4) the program's milestones and related events; and (5) a list of all of the resources needed for T&E (Reynolds, 1996). Reynold complements the contribution of Sydenham (2004) and Barret *et al.* (2009) to include the operational and disposal phases as the former may reflect many deficiencies in real-life operations while the latter inform the testers and evaluators the reasons that lead to end the life of a product.

Essential products and processes require more intensive T&E due to their sensitivity. Projects can therefore be assigned three risk categories (Table 2-10) based on cost, technology and production scale (Reynolds, 1996). Enterprises such as AVMs and other defence-related products/processes are assigned to the third category, characterised by low production numbers but high costs and advanced technology.

Risk		Low Cost High Production	High Cost Small Production Low Technology	High Cost Small Production High Technology
Development Risks	Cost			X
	Schedule			X
	Performance			X
Production Risks	Cost		X	X
Marketing Risks	Share of Sales Markets	X		
	Return on Investment	X		
In service Risks	Operability			X
	Reliability			X
Disposal Risks	Cost			X
	Safety			X
	Environment			X

Table 2-10. Three risk categories. AVMs (defence industry) lie to the extreme right due to their high risk (Reynolds, 1996).

Reynolds (1996) adds that "*These programs involve significant development risk, because of the use of state-of-art technology; production risks because they operate in unique environments with dedicated logistics support infrastructure; and sometimes disposal risks, because they use relatively new materials for which the long-term environmental impact is not fully understood and for which safe and efficient disposal techniques have not yet been fully developed*". This argument emphasises the importance of T&E for AVMs' products and the development process. However, these activities must be performed with the contributions of leading players, such as customers and subsystem providers.

Weiss *et al.* (2009) claim that enterprises fail to achieve such goals because they do not involve their stakeholders, they focus on technical issues with little attention to managerial aspects, they adopt a ‘quick-fix’ approach which resolves product/process defects instantly but increases production costs, and they fail to ensure the integration of real T&E programs into the enterprise strategy. Moreover, Weiss *et al.* (2009) lists some issues that lead to failure of T&E such as failing to specify customer needs precisely, especially operational needs. This failure leads to the incorrect or inaccurate specification of requirements which affects the T&E measurements and standards that are applied. Secondly, insufficient knowledge of the subsystem parts, which affects the performance of the major product as well as production costs and time. This deficiency also affects the progress of the T&E program and its quality. Thirdly, inadequate requirement standards which form key performance parameters (KPPs) as the primary driver of the T&E program. Fourthly, inadequate T&E scheduling, leading to late testing. Lastly, a lack of cooperation and coordination among the stakeholders.

One solution to overcome such deficiencies in an essential program (process) is the formation of a third-party credible entity that is responsible for developing and managing T&E with specialised resources (Eigbe, Sauser and Boardman, 2010). This body must have one objective: to ensure that the product and its development programme has passed through project essentials “*such as project planning, project assessment and control, decision management, risk management, measurement, and information management*”, where T&E can then be easily integrated and applied within the different development process.

Eigbe *et al.* (2010) directs managements to create appropriate tools to ensure the T&E schedule integrates with the development milestones designated throughout the project’s life-cycle. Also, they emphasise on ensuring adequate training so that all individuals have the appropriate knowledge to enhance the competencies of the T&E teams within and outside the organisation. Moreover, they encourage different enterprises to acquire a certain level of T&E professional credibility. The T&E experts within the enterprise will then be unbiased and will work at an equal distance from both the enterprise and their stakeholders. It is important that this last effort must be followed by establishing a T&E strategy as a crucial requirement for the high-level authorities to ensure that all concerned national industries follow suit. However, these strategies require enterprise leaders and managements to prepare business strategies to support such a direction. And lastly, there must be continuous improvement as lessons are learnt from real T&E scenarios, to approach best practice.

Therefore, one can recognise that T&E is not an optional element of product and process development, despite the cost burden, and all stakeholders must consider it as a key element of the development process and must be prepared for the best results. This initial cost will disappear when one considers that the system, after deployment, will have no unexpected defects and will therefore achieve customer satisfaction. However, the cost of unforeseen defects after deployment is far higher than the cost of remedying these defects during production. Adopting a T&E program benefits all stakeholders, and independent local T&E organisations offer many advantages, including the progress of the industry itself.

Finally, Figure 2-18 shows how the application of SoS application can enhance the overall network T&E by always upgrading each constituent's system based on the changes in the external environment. Furthermore, this figure highlights the importance of a higher-level authority to control the entire process and continue to monitor the evolution of the SoS architecture. Thus, the relationship between the T&E and SoS is distinct and must be maintained.

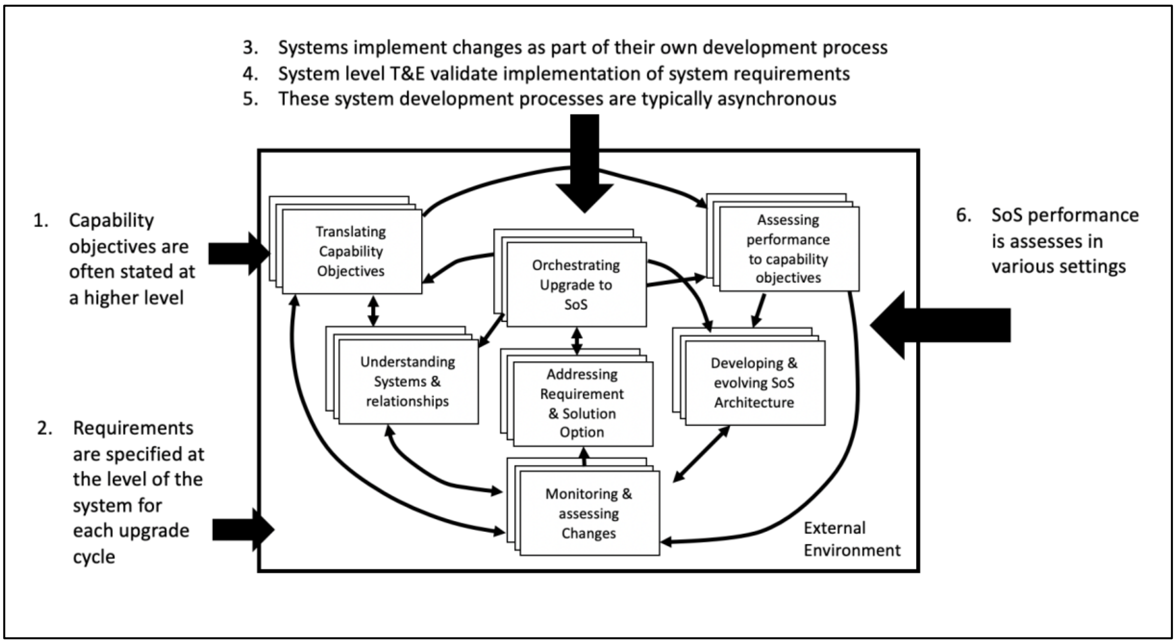

Figure 2-18. SoS elements and their relationship to T&E (MITRE, 2012).

2.7.1 Summary

Many AVMs underestimate the importance of the T&E, or they ignore it because they consider it a costly inconvenience without explicit return. Some AVMs may apply the tests, but ignore the evaluation. However, the test process may be insufficient or inappropriate due to the lack of measurements and standards. The T&E must be a strategic decision and should be organised at an early stage in the development process, i.e. during the design phase. Customers and subsystem suppliers must be involved and kept informed during all T&E steps, which must be implemented at development stages with predefined milestones. The production process must also be tested and evaluated for quality purposes. The involvement of customers improves customer satisfaction and satisfaction builds at the moment the customer begins to participate in the T&E program. The availability of third-party T&Es will reinforce the AVM network (supply chain) and ensure the credibility of the process. Figure 2-19 summarises the relationship between T&E and customer satisfaction.

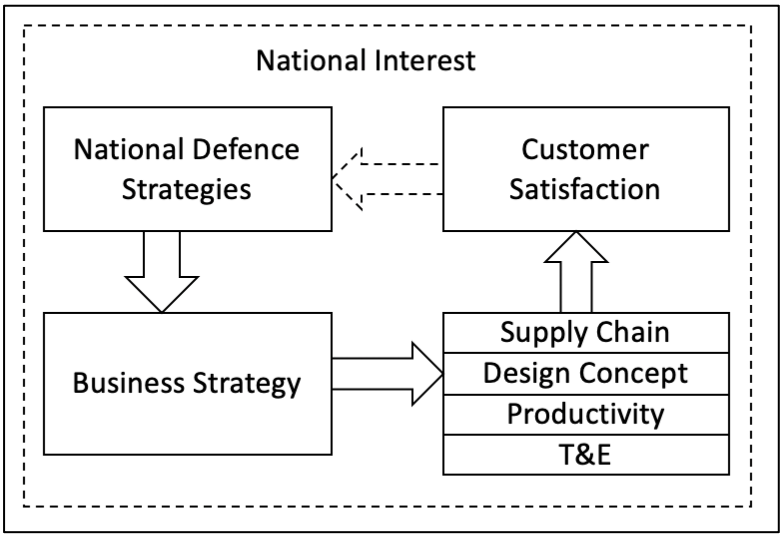

Figure 2-19. The impact of T&E on customer satisfaction (Author).

3 Customer Satisfaction Enablers

3.1 Introduction

The author has provided managerial tools that can enable managements to enhance their value developing process and ensure customer satisfaction. Furthermore, the author strongly believes in two essential enablers that improve the practices of managerial tools such as interaction and system engineering. The former helps managements to break down all boundaries between different participating parties to reach a pre-specified goal. Where the latter integrates different processes (managerial and technical) to achieve optimum results. The next two sections (3.2 and 3.3) will discuss these two essential subjects and how they contribute to enhancing customer satisfaction.

3.2 B2B Interaction as an Enabler to Enhance Customer Satisfaction

3.2.1 Introduction

AVMs are SMEs mostly owned by entrepreneurs alongside professional management staff. They deliver remarkable products to defence customers with professional (highly-skilled) individuals in different fields (operation, technical and financial). The business between these two parties is supposed to be in the form of "*Relationship marketing*" which "*encompasses the study of interactions*" (Sarmento, Simões and Farhangmehr, 2015). Sarmento *et al.* (2015) added that "*the management of the interaction process is particularly relevant in industrial marketing and in B2B situations because firms establish buyer-seller relationships which are often characterised by being close, complex and long-term".* The author of this thesis prefers to call such relationship marketing "business to business (B2B)". Kotler *et al.* (2003) describe B2B to involve continuous interactions among highly-skilled individuals from both sides (seller and buyer), which is more difficult than business to customer (B2C) practices where there is more of a unidirectional relationship, from highly-skilled suppliers to less-skilled customers. Although B2B is derived from the basic B2C model, B2B involves complex interactions that must be evaluated to determine the main factors that influence customer satisfaction (Lilien, 2016). Therefore, the author of this thesis avers that more attention should be paid to how the B2B relationship is arranged to achieve customer satisfaction. Moreover, this relationship is affected by the dynamic environment, where competition is intense and customer requirements dramatically change as unexpected threats arise (Hadjikhani and LaPlaca, 2013) which involves complex interaction among various parties. Kotler *et al.* (2003) and Hadjikhani and LaPlaca (2013) clarify the importance of such practices in enforcing the relationship among the individuals from both sides especially in the presence of dynamic environments. Part of the dynamic environment is AVMs being SMEs in that they differ from large enterprises in the sense that only limited resources are available to deal with customers and environmental factors, making it more difficult to achieve organisational goals, including customer satisfaction. These firms, which do not have adequate internal resources and technical capability, might supplement them with external interactions and support. Bala Subrahmanya (2015) acknowledges that "*firms which are relatively well-established are likely to have more resources and such firms are likely to be older and larger in size*". The next section aims to browse the best practices regarding the relationships between the providers and customers to capture customer satisfaction concerning enterprises as SMEs in dynamic environments. The section will describe what customer satisfaction means and then identify the best practices of B2B, given the different types of possible interactions between developers and their organisational customers.

3.2.2 The customer satisfaction concept

Customer satisfaction has been defined as the feeling resulting from a comparison between the value offered by a provider and the customer's previous expectations (Kotler, 2003). Yaqub *et al.* (2010) defined satisfaction as "*a positive affective state resulting from the appraisal of all aspects of a firm's working relationship with another firm"*. The two previous definitions simply clarify the process of gaining satisfaction which can be described as three main actions: (1) creating an appropriate image in the mind of potential customers to raise specific expectations, (2) using the enterprise's competencies to deliver value that reaches or exceeds these expectations, and (3) enforce the interaction among different parties. It follows that customer satisfaction can be determined by the resulting gap between the created image and the actual value provided (Varela-Neira, Vázquez-Casielles and Iglesias-Argüelles, 2008). Customer satisfaction is a target that helps enterprises to achieve profit and market sustainability (Ganiyu, Uche and Elizabeth, 2012). Thus, one can say that enterprises deliver two crucial things: value and satisfaction (Zhang, Zhang and Law, 2014); where value is an accumulative of many means such as physical product, services, beneficial interaction, etc. However, customers should have a defined image (perception) which should then be approached or exceeded by total values delivered. It can be concluded that the defined image and better delivered values require intensive efforts and interactions among most critical parties to approach the intended satisfaction.

After browsing many literatures, the author of this thesis is more comfortable with to Barnes' model of customer satisfaction five-levels as it gives more detail. Barnes (Barnes, 2001) presents customer satisfaction as a cone with five levels (Figure 3-1), starting from the base: (1) the core product, (2) delivering services and products, (3) technical performance, (4) customer interaction, and 5) emotions. Many other models limit the customer levels to only three levels: base expectation, selection among specification and requirements, and delight where the customer received over-expected values (Kotler and Keller, 2015).

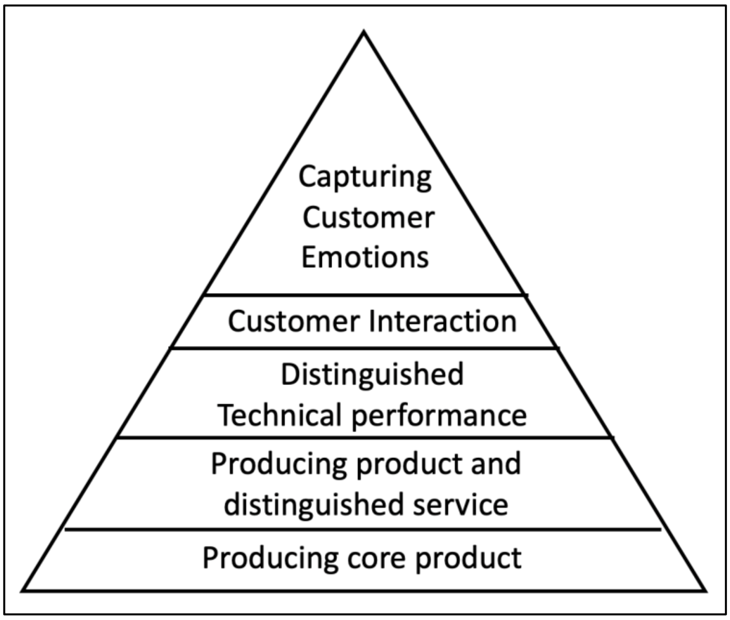

Figure 3-1. Barnes Customer triangle (Author).

According to Barnes, customer satisfaction starts from the second level, because the first level is the minimum threshold for an enterprise to join the industry and start to initiate relationships with potential customers. On the second level, customers start to recognise that the enterprise produces value that differentiates it in terms of better covering their needs and seeking their satisfaction. These values include the core product or service, and the interactions combine with the necessary information to add more value to the core product. The third level delivers the core product plus other preferences that customers feel during the use of the product. This involves interactions that enable the developer to understand the explicit and latent customer needs. On the fourth level, the enterprise tries to improve these basic interactions with the customer to build mutual confidence. This allows the customer to share decisions with the developers for better overall results. As a consequence, the customer, beyond the fourth level, has more trust in the product, and the producer, due to the good relationship and better product quality, achieving satisfaction earlier. In addition, the involvement (which is one form of a trusting relationship) reduces the cost of late reworking and alterations that may be necessary during the development process if the customer is unavailable. Thus, commitment, trust and customer involvement push toward the top level of the cone, a positive emotion also known as the affective dimension, where the real feelings of the customer become apparent. Barnes concludes that the satisfaction cone is an excellent guide for enterprises seeking customer satisfaction which is a prime component of a competitive advantage. Moreover, the satisfaction cone encourages management to improve customer perceptions of delivered values by engaging in closer interactions to ensure consistent relationships, customer satisfaction and customer loyalty.

Customer satisfaction can be expressed by the Expectancy Disconfirmation Theory (EDT) where customers' expectations can affect their purchasing processes and post-purchasing satisfaction (Krishnamurthy and Kumar, 2015). According to Lee and Cho (2016), expectations are pre-consumption beliefs about the performance of the product based on the information provided by the developer, mostly before producing it. If the customer, after acquiring and using the product, experiences something different from the pre-purchased expectation, this will affect their consumption experience (satisfaction) (Ofir and Simonson, 2007). Thus, satisfaction is the gap between the feelings before purchasing (expectation) and after purchasing (real).

Moreover, Lin and Lekhawipat (2016) use the EDT to understand customer satisfaction. This theory assumes that customers initially form certain expectations about the product's functionality and features based on the information provided by the developers or other sources. These expectations are later compared to the customers' perceptions that they gain as they use the product. The difference between these two feelings is known as "disconfirmation of expectations", as shown in Figure 3-2. If the product performs better than the customer expected, then a positive disconfirmation would be the result; otherwise, a negative disconfirmation occurs. According to the EDT, the better the performance of the developed product (the more positive the disconfirmation), the greater the customer's satisfaction level will be (Lankton and McKnight, 2007). Meanwhile, Santos and Boote (2003) elaborate on the types of customer expectation and level of satisfaction, as well as

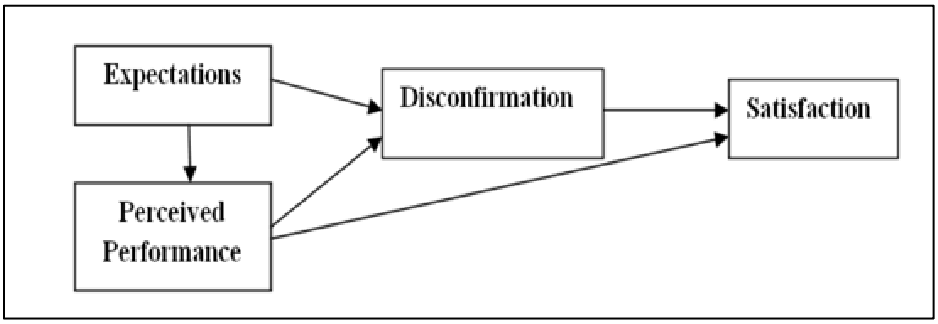

Figure 3-2. Expectation disconfirmation theory (Elkhani and Bakri, 2016)

the consequences of each satisfaction. They distinguish between the different expectations to include dissatisfaction, acceptance, satisfaction and delight. Santos *et al.* (2003) conclude that developers should trace the types of expectation to predict satisfactions and the affective action which either benefit or harm the reputation of the produced value via world-of-mouth (WOM) and thus the reputation of the enterprise.

The above contributions by the different scholars of customer satisfaction reflect two prime issues that developers' management should consider. The first issue is the understanding of customer expectations of what they wish to get. The second issue is to provide specific values that meet or exceed their expectations. Furthermore, satisfaction is a build-up emotion that starts with the value delivered threshold and can be elevated to reach the peak of the Barnes' triangle or the delight status as described by Santos *et al.* (2003) and Lin and Lekhawipat (2016). Nevertheless, understanding customer expectations conveys the actual value in the customers' mind and delivers value that exceeds their expectations. This requires appropriate interactions between the developers and customer organisation, which will be covered in the next section.

3.2.3 Customer satisfaction within B2B practices

As mentioned earlier, the interaction between AVMs and military organisation customers is a B2B relationship, the strength of which depends on the level of the interaction among individuals at all organisational levels, based on involvement, trust and commitment (Yaqub, Malik and Shah, 2010; Pilav-Velic *et al.*, 2015; Sarmento, Simões and Farhangmehr, 2015) (Figure 3-3) . Such a relationship must benefit both sides through a win-win outcome, which enhances customer satisfaction. The following sections discuss some of these factors in detail.

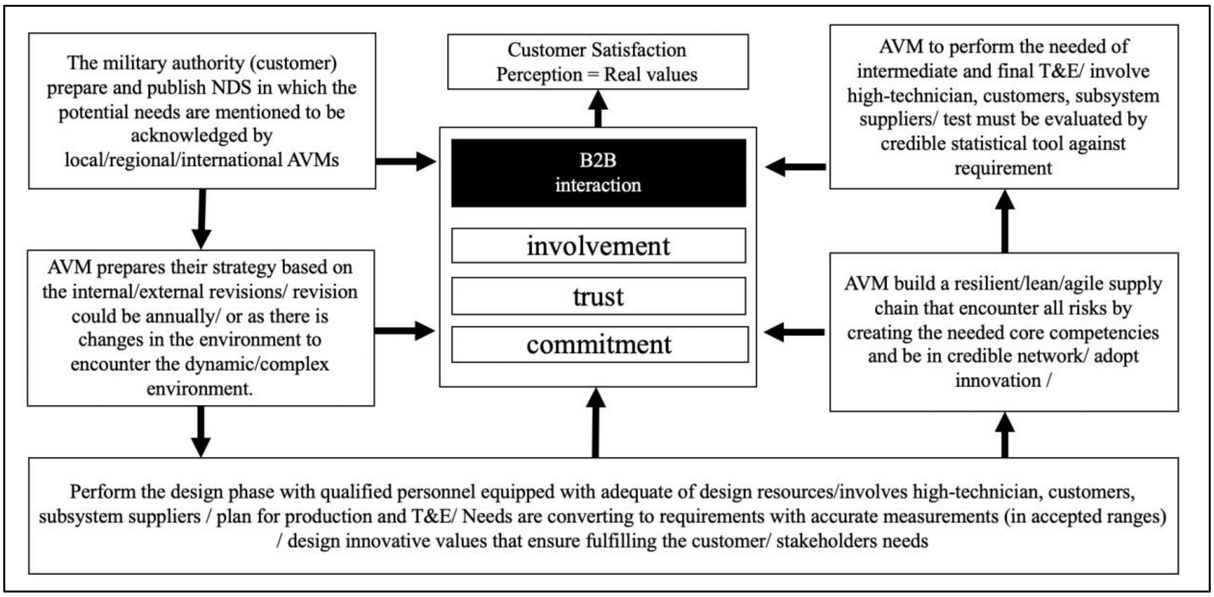

Figure 3-3. The customer satisfaction model of B2B relationships (Author).

3.3 B2B interactions

The stakeholder theory urges an enterprise to establish a network that encompasses all of the stakeholders needed to achieve specific, shared goals. This network is based on allies who deliver similar values. Thus, the competition is not between enterprises but rather between networks (Kotler, 2002). The strength of the network depends on how different entities experience collaborative efforts that unite different functions and elements to perform pre-specified tasks, allowing them to reach common and consistent values (Toma, 2011). The Kotler (2002) and Toma (2011) arguments are more effective if the network constituents belong to a single group, i.e. nation or geographic region. What is important here is how to establish a strong relationship that benefits all of the stakeholders within the network. However, such a network might be enforced by the national authorities to enrich interactions among different (national) parties and to achieve essential integration and interactions. The national authorities may also seek to extend the network to include regional and international entities. This fact paves the path for the Gulf States to create a unique network that will increase the interaction among the different parties at both levels: national and regional. Nevertheless, interactions eventually aim to capture customer satisfaction (Mishra and Mishra, 2009), as clearly depicted in Figure 3-3.

Interaction can be defined as the willingness of different parties to exchange values of interest (Hadjikhani and LaPlaca, 2013). The intended interaction is wealthy if all parties gathered to reach one goal in a network (Liao and Kuo, 2014). Hadjikhani and LaPlaca (2013) and Liao and Kuo (2014) affirm that interaction requires a healthy medium (network) which is necessary to be formed to pursue predetermined goals, at both the enterprise and national levels, by exchanging the pre-set benefits among the constituents' parties within the created network. However, the interaction may discontinue if the mutual intended goals are reached or suspended. This is the case even if the status of the exchange is idle for a period of time because it can easily be reactivated at the request of one of the parties. For example, a customer may need additional deficiencies to be addressed by the same provider, or the same product may be requested at a later date by the same customer, so the relationship is likely to be resumed. The time between developing projects ordered by a customer might be so long that the lack of communication between parties weakens the interaction.

Interaction tends to be dynamic because it combines four main exchanges: financial, product, social, and information (Cătălin, Andreea and Adina, 2014). For example, when there is no product exchange, enterprises management may continue the interaction by exchanging information or hosting social events. Therefore, enterprise management must select the best combination of these four exchanges and the most appropriate interactions that enhance customer satisfaction. This orientation is supported by Cambra-Fierro *et al.* (2013) as the interaction is reinforced by the involved parties exchanging valuable information in order to understand their mutual needs and discuss future business. Therefore, the strength of the interaction requires enterprises to be close to their customers and to establish early interactions with different customers in order to exchange valuable information that can be used to enrich the development of new products (Carbonell, Rodríguez-Escudero and Pujari, 2009; Lyons *et al.*, 2012). However, gathering information from customers, especially military ones, may be difficult, and requires frequent and reliable communications as well as planned events to reinforce future coordination with the customer (Fang, Palmatier and Evans, 2008). It is obvious that all of the above-mentioned customer satisfaction scholars urge management developer entities to avoid relationship discontinuation in the event of low or no exchange of value by activating various initiatives in the form of financial, product, social, or information exchanges. It is recognised that such constant interactions benefit all parties and it appears that customer interaction is a key factor in subsequent business success.

However, Ahearne *et al.* (2012) recalled several issues that can affect developers-customer interactions. Firstly, customers are often displeased with salespersons because their visits are either too frequent or too infrequent. Secondly, some customer organisations require many communication channels to be established in order to achieve effective interactions and improve customer integration to "*create a holistic view of the customer*". Other organisations have multiple channels and many influencers and decision-makers, which requires great effort on the part of the producer to allocate resources, even before a sale has been initiated. The latter facilitates an understanding of the customer's viewpoint and promotes knowledge transfer, which in turn compensates for the cost burden of forming a sales team. Thirdly, the poor understanding of the customer structure, culture, and behaviour may have negative consequences. Moreover, Loh *et al.* (2011) highlights some difficulties that hinder the SMEs like AVMs to interact with their customers such as the lack of knowledge on how to deal with customers, the lack of financial resources to burden the cost of dealing with customers, and the lack of social skills. Ahearne *et al.* (2012) and Loh *et al.* (2011) highlight some of the practices which the author of this thesis has observed on various occasions. These issues may lead to a discontinued relationship and loss of business.

To overcome some of the above-mentioned issues Ploetner and Ehret (2005) introduce some helpful strategies such as: assigning the role of each individual interacting with the customer and the situations that determine their obligations during contact, identifying the points of contact on both sides, and deciding which actions are needed on each side before taking the decision. However, dealing with such issues and solutions require appropriate interactions' strategies and efficient implementations to these strategies, especially with SMEs controlled by entrepreneurs. It can be concluded that both strategies (NDS and BS) should contribute toward setting the appropriate interactions through reliable networks and a decent supply chain. The next three sections address the three means to encourage interactions between enterprises and their stakeholders: involvement, trust and commitment. These three principal elements must be part of the two main strategies.

3.3.1 Involvement of customers and subsystem providers

In the author's experience, there is no clear strategy for customer involvement in most of the AVMs in the Gulf States, and there are several reasons for this[6]: (1) limited customer knowledge compared to state-of-the-art technology that makes involvement futile, (2) the fact that the development process is completely in the hands of AVM personnel, and (3) management styles that restrict customer interactions. Indeed, the level of involvement is an indication of how far customers are welcomed by developers like AVMs to participate in the creation of value that covers their current and potential needs. Involvement is an exchange of information between different parties that produces appropriate decisions and builds better. The customer, rather than the product, is the key to productive involvement (Kotler, Armstrong and Chawla, 2003). Furthermore, customer involvement requires good communication, close participation in product development, and gamification (Piligrimiene, Dovaliene and Virvilaite, 2015). While communication and participation are familiar concepts, gamification is the use of "*game design elements*" to strengthen customer engagement by improving their perception of the value offered (Huotari and Hamari, 2012). However, such involvement is limited to customers roles, types of customer participation, and levels of involvement based on the developer's strategy (Vaisnore and Petraite, 2011). It is clear that developing new products without customers' involvement would lead to a one-sided view of the design team, where the operational features would be questionable. To benefit from

[6] Based on the author's experiences which are enforced by opinions from AVMs' key-informants

customer involvement, developers must adopt the appropriate strategies that comply with what the scholars mentioned above. These strategies must determine both the level of involvement and role of customer along the development process.

Adopting a strategy is not an option as developers may benefit from customer involvement, for example: by increasing profit, promoting their brand, attracting new customers, and capturing customer loyalty (Piligrimiene, Dovaliene and Virvilaite, 2015). Moreover, customer involvement encourages innovation by generating new ideas and increases word-of-mouth (WOM) advertising, which in turn has a significant result in terms of market expansion, greater market insight received from the customer and, more importantly, free access to the customer's premises to understand the customer's real needs close to where the developed product will be used in real-life operations. There are also benefits of customer involvement on the shop floor, when customers are invited to attend different stages of the manufacturing process, share their military operational knowledge and monitor the assembly of their product during the early stages (Kujala, 2008). It is clear that these benefits attract management to give the highest priority to plan for better of customer involvements. However, Wimalachandra et al (2014) noted some disadvantages from customer involvement related to "*confidential information*" which can be transferred to competitors especially in "*high-technology product development*".

Even so, the role of customer involvement depends on the "*time frame, the nature of business exchange and the role of the customer, managerial mind set, the enterprise's interaction with customers and how it develops products and the purpose and flow of customer communication values*" (Vaisnore and Petraite, 2011). For example, buying off-the-shelf products due to time shortages is the lower level of involvement, where limited information is required to convince customers about the value of pre-made product, which may cover only part of their needs. This is known as "informative involvement" (Figure 3-4).

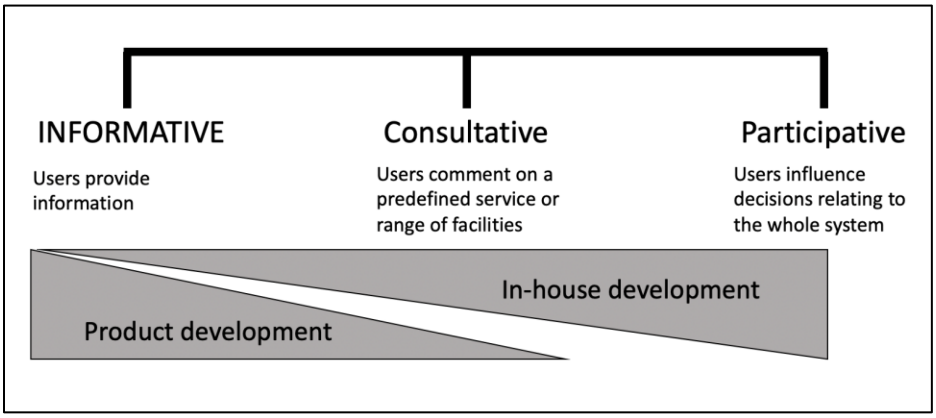

Figure 3-4. Forms of user involvement (Kujala, 2008).

The level of customer involvement can be defined as informative, consultative or participative (Kujala, 2008). Informative involvement, at one end of the spectrum, is the minimum level of customer involvement, where the developer is fully responsible for the design features based on information supplied by the customer (or the developer's opinion of the most desirable features on the market). Participative involvement, at the other end of the spectrum, is an iterative type of decision-making, where the customer is considered an essential component in the development process, and this leads to a product with customised values that cover almost all the customer needs. Consultative involvement, midway between these extremes, involves customer interactions limited by the nature of customer enquiries and the responses of experts representing the enterprise.

According to the author's understanding, AVMs in the Gulf States tend to engage in participative involvement, but this depends on the purchasing circumstances. For example, one of the AVMs deals with their customers via a third party, and the authorities buy their vehicles and send them to the users, normally foreign governments, via military aid programmes. There is little or no customer involvement in this case. From initial visits, the author recognised that the off-the-shelf strategy used by another AVM also leads to the minimal customer involvement. Other AVMs allow consultative involvement, whereas participative involvement requires far more capability, knowledge and planning on the part of the customers. Also, the author explored that some AVMs argue that poor customer involvement may cause project delays.

Customer involvement may also depend on the time frame, e.g. if the product is needed urgently or within a previously planned delivery window (Vaisnore and Petraite, 2011). The time between recognising the customer's needs and delivering the product is an important determinant guiding the type of involvement. For example, urgent needs, as mentioned above, favour informative involvement whereas long-term needs offer more room for participative involvement. One of the most important issues related to involvement is the management's mind-set (Vaisnore and Petraite, 2011). The management of certain organisations may encourage customer participation while others may refuse to exchange knowledge with their customers. However, the customer's role may force the management to allow consultative or even participative involvement, even if this goes against their normal practises. Based on information gathered by the author through the initial visits to AVMs, AVM managements in the Gulf States blame the defence authorities for not raising their order in a sufficient time period so that appropriate acquisition systems can be put in place. They argue that customer involvement requires additional time and this should be added to the total development time during the early stages rather than delaying a set delivery date due to a customer's sudden and unexpected involvement.

One factor that helps customers to benefit from their involvement and eliminate some risks is national similarity with the providers, and this also determines the level of involvement (Brodie *et al.*, 2011). This is clearly the case for many AVMs in the Gulf States, because the owner and higher management are the same nationality as the majority of customers. It has been recognised that these enterprises (AVMs in the Gulf States) are likely to deal with them based on security dimensions but also shared language and culture as well as proximity. For example, if the national military faces a problem or deficiency, they will first contact local/national providers. National similarity evokes emotional, cognition and behavioural cues which lead finally to that the customer interacts using two-way communication, which represents the depth of the involvement (Brodie *et al.*, 2011). The national similarity is the strongest motive that leads to establishing local defence manufacturers to enable local customers to deal efficiently with the developer to fulfil their needs. Concerning the situation in the Gulf States, the national similarity may be extended to include the six countries because of the cultural similarity among them.

The subsystem suppliers may also be involved in the development process, which is just as significant as the involvement of the customer. It has been known that AVMs depend to a large extent on their suppliers providing high-quality raw materials (armoured plates) and subsystems (auxiliary systems) to determine the quality of the final product quality, which includes trusted protection vehicles. Enterprise designing new products must be aware of the parts that are required and the way they are integrated, therefore it is critical to involve the suppliers to achieve overall end-product quality (Menguc, Auh and Yannopoulos, 2014). It is likely that a subsystem supplier will be a business partner, especially when the supplier acquires high bargaining power, as it is easier to build a relationship with the supplier than with the customer (Kooli, Mansour and Cornwell, 2016). Moreover, the need for an innovative product with up-to-date technology forces the product designer to invite suppliers to share their ideas. This ensures the enterprise assemble high-quality products with a competitive advantage (Lawson, Krause and Potter, 2015). However, the involvement of suppliers varies, from providing technical information to assuming full responsibility for the design of the components, systems, and processes, all of which results in a better product (Menguc, Auh and Yannopoulos, 2014). The selection of subsystem suppliers is essential for the success of the prime product. Von Massow and Canbolat (2013) explained the criteria for selecting credible suppliers within a reliable supply chain. They insist that the supplier is "*a source of value for the firm*" as the former should acquire significant attributes and produce a significant product (subsystem) (von Massow and Canbolat, 2013). Habermann *et al.* (2015) prefer to acquire subsystems from co-location suppliers which have substantial effects in terms of mitigating supply chain disruption and reducing delivery duration. Other criteria include supplier efficiency, procurement cost, and delivery time (Dotoli, Epicoco and Falagario, 2015). Supplier involvement has a positive effect across a range of different performance outcomes in terms of reducing material costs, improving material quality, shorting the development time, reducing project costs, enhancing product functionality, improving product manufacturability, lowering manufacturing costs, and accessing supplier technology (Lawson, Krause and Potter, 2015). It can be concluded that the closer location justifies most of the selection criteria to encourage involvement besides the national and cultural similarities which enable similar individuals to interact with each other efficiently. However, the quality of the selected providers must be maintained.

3.3.2 Trust between providers (AVMs) and their customers

"*Trust is a cornerstone in developing and maintaining business relationships*" (Çerri, 2012). Welter (2012) highlights some common keywords that indicate both personal and collective trust, such as "*reciprocity, expectations or beliefs about the intentions and trustworthiness of others*". Reciprocity explains the equality of feeling between the trustor and trustee. Mandina (2014) defines trust as "*the willingness to rely on an exchange partner in whom one has confidence*". In addition, Raimondo (1995) defines trust as "*the willingness of one party to be vulnerable to the actions of the other party, by the expectation that the other one will carry out a particular action for the trustor, irrespective of the ability to control that party*". The word *willingness* shows that both parties are comfortable dealing with each other in full confidence. In addition to reciprocity, expectation, beliefs and willingness, Raimondo (1995) links trust to the perception of the actors: trust is "*related to the perceptions of counterparty's reliability, ability and absence of opportunism*". He adds that trust is a combination of emotional and cognitive principles, because the two dimensions lead to different types of trust, which is necessary to initiate and maintain a relationship. Although perception is an emotional status, it also massively affects trust. Raimondo (1995) introduces two additional factors: integrity and benevolence. In real-life situations, a trustor and trustee need physical elements, such as quality evidence, to prove integrity. Benevolence, on the other hand, exists as one party tries to avail the other before the other attempts the same. Once again, ability, integrity and benevolence are elements that reinforce the partnership of trust among different parties.

In a study of B2B relationships in the service industry (the principles of which are equally relevant in the manufacturing sector, discussed in this thesis), trust can be divided into two essential elements: credibility and benevolence (Doney, Barry and Abratt, 2007). Credibility is the ability of enterprises to fulfil their promises, where benevolence is the belief that neither of the partners (enterprise or customer) will take any unexpected actions that would harm the relationship. The trust-related keywords (reciprocity, willingness, integrity and benevolence) listed above are essential for the relationship between an enterprise and its customers, especially military customers. However, this trust is based on reciprocal perceptions.

As a rule of thumb, the perception element has one of the most critical effects on the construction of real trust. Raimondo (1995) explains that one party should have a perception of another with regard to two attributes: ability and motive. For example, if the customer perceives that a provider has both the ability and motive to accomplish their request efficiently, the customer will trust this provider. Ability relates to an enterprise's competency, whereas compensation, knowledge, and self-confidence are examples of motives. The customers' perception influences the level of trust. For example, during the author's career, he has faced many issues related to the competency and trust of AVMs. As a customer, the author and his co-team members attempted to confirm the AVM's ability to produce the required values by informally assessing the knowledge of shop-floor managers and technicians through natural dialogue about, for example, the welding process, which might reflect the competency of the AVM. On the other hand, the author has also observed that the shape and setup of a shop floor, as well as the manufacturing buildings, can affect customer perceptions, which might affect decision-making. On many occasions, the decision made is based on the acquisition team's perceptions prior to conducting the cognitive thinking.

For trust to be established, essential factors are needed. Doney *et al.* (2007) creates a good remarked summary of the three social behaviour factors that initiate and maintain trust: social interaction, which builds the required trust if the social bond between the two parties approaches the benevolence behaviour level; customer orientation, which is needed to acquire trust as developers strive to understand customer needs by establishing an enduring relationship; as well as open communication, in which both parties "*communicate openly, sincerely, and substantively with customers either formally or informally*". These three types of interactions ensure the shortest route to a closer interpersonal relationship among the individuals in different organisations (the producer and the customer). In the same context, Arifin (2015) researched the factors that create and enhance trust to achieve better, more successful B2B relationships, and thus customer satisfaction. Arifin (2015) has been asking: "*what are the antecedents of trust in the B2B buying process?* He listed all factors that create the initial trust which are based on belief, and this behaviour gradually enhances trust, as shown in Figure 3-5. This figure stimulates the trust between the developer and their customers, and can be taken as an index for evaluating the future success of any enterprise. Moreover, Alves *et al.* (2012) remarked a very important consequence of trust as they mentioned that "*trusting relationships are likely to have lower transaction costs".*

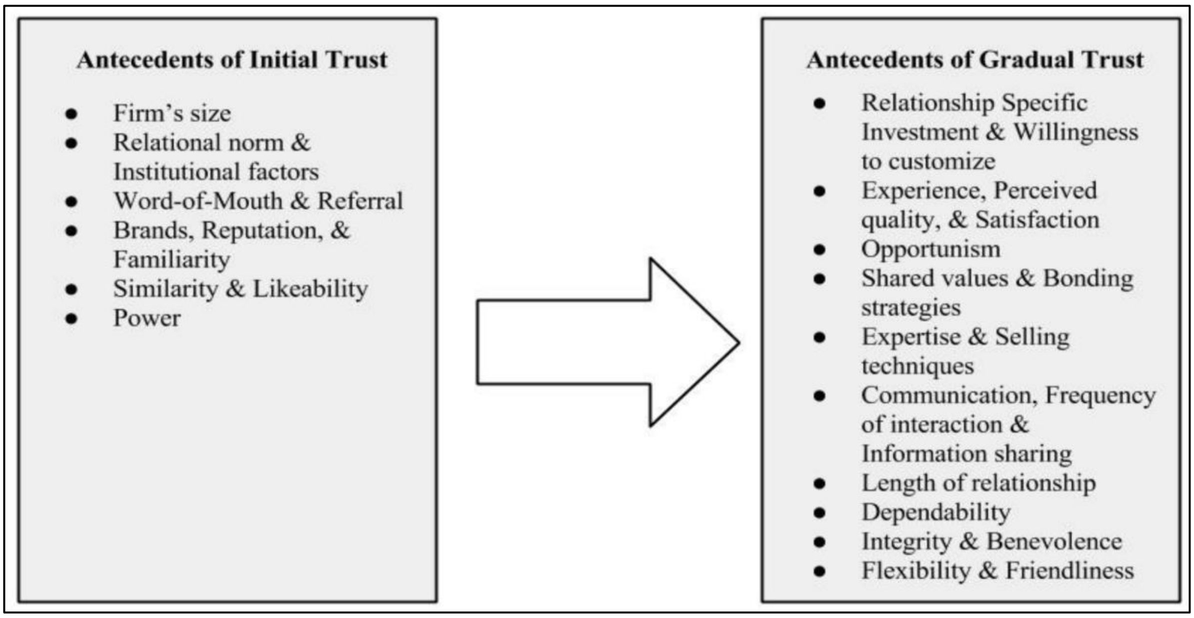

Figure 3-5. Antecedents of initial and gradual trust in B2B relationships (Arifin, 2015).

To give an example from the Gulf Area, Abosag and Lee (2013) interviewed 15 managers in two different years (2003 and 2008) to investigate the life-cycle stages of the B2B relationship: pre-relationship, early interaction, growth, and maintenance. The study considered factors that help to form competence trust and effective trust in a country like Saudi Arabia. Competence trust is "*the expectation that partners can fulfil their roles*" and effective trust is the "*feeling of security and perceiving the strength of the relationship*" (Abosag and Lee, 2013). However, the development of trust can differ in different cultures. For example, developed and developing countries have different incubation periods for building such a relationship. In this context, Abosag and Lee (2013) cite an empirical example from the Gulf States, where relationships were substantially affected by many emotional antecedents, such as family relationships and friendships. This is because trust between individuals in such countries depends, to a great extent, on family origin (one party) and the strength of the relationship with other families (another party).

This led Abosag and Lee (2013) to introduce the concept of *Et-Moone* relationships, in which strong friendships are more effective in building trust. An *Et-Moone* relationship must contain five main factors: positive past interaction, trust and a strong relationship commitment, a strong personal friendship characterised by high levels of empathy, liking and reciprocity, and mutual acceptance of power-sharing and decision-making. The study considered the extent to which culture affects trust factors. The Arabian Gulf culture may ignore some of the trust factors or at least dilute them, if family or friendship ties exist. From the above factors, positive past interaction can be a source of blind trust regarding future deals, and friendship ties allow forward commitment (an implicit rather than explicit or documented agreement) to become an essential part of Arabian Gulf relationships. These types of cultural behaviour increase trust among the players and the B2B cooperation, which leads to an efficient outcome. These factors have been confirmed by AVM managers in the Gulf States, especially those from a different region compared to their customers.

Arifin (2015) and Abosag and Lee (2013) introduced the essential elements (antecedents) to ensure the necessary trust, thus leading to satisfaction. The study of trust in B2B relationships has been extended to include the many aspects summarised in Figure 3-6 (Alves, Campos and Oliveira, 2012), but further analysis can resolve these factors to five main factors: (1) the amount of information available, (2) professionalism and commitment, (3) international presence, (4) cooperative norms, and (5) monitoring.

Of the abovementioned factors, the author thinks international presence is significant in the sense that these enterprises are sufficiently competent to compete with enterprises operating in developed countries. The author strongly believes that customers (military organisations) in the Gulf Area are likely to deal with these types of AVMs, believing they are more qualified and can bring better technology to their requested product.

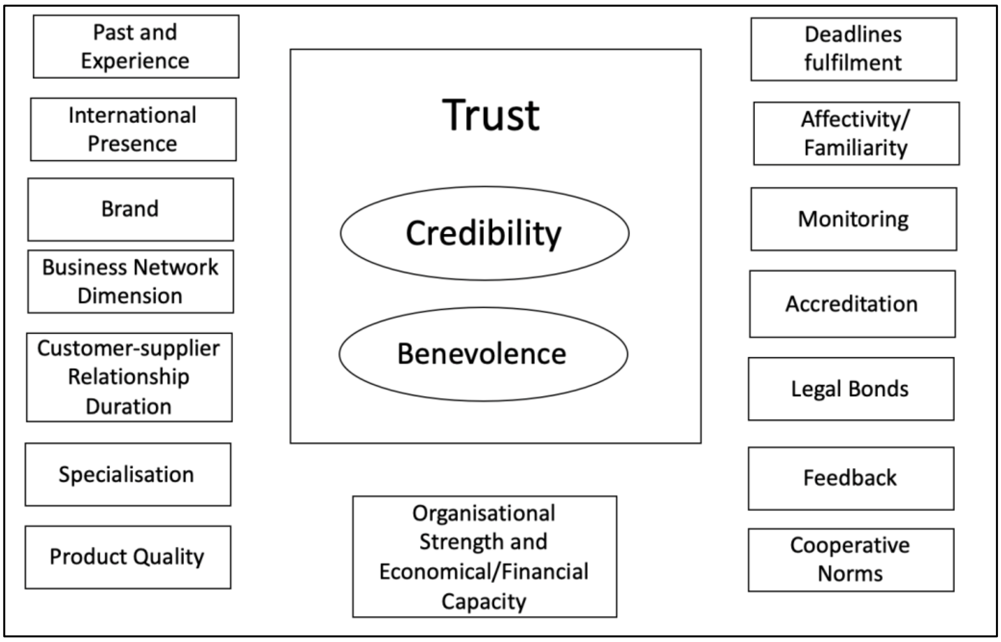

Figure 3-6. Determination of the trustworthiness of a supplier (Alves, Campos and Oliveira, 2012).

3.3.3 Commitment in B2B relationships

Finally, mutual commitment is essential for any project because cumulative efforts are needed within a dynamic environment. Commitment in a relationship can be defined as an "*enduring desire to maintain a valued relationship*" (Christine Moorman, Gerald Zaltman, 1992) or as "*the willingness of a party to invest financial, physical or relationship-based resources in a relationship*", especially the willingness of the producer to invest in the customer in order to maximise the mutual benefits for both parties and ensure a longer relationship (Zhao *et al.*, 2008). Indeed, involvement and trust lead to commitment (Morgan, 1994; Gustaffsson, Johnson and Roos, 2006).

A relationship may be initiated by a developer that introduces unique value (a quality product) which exceeds the value provided by competitors, thus achieving customer satisfaction. This requires successful "*adaptation, knowledge transfers, trust and cooperation*", which would allow further beneficial relationships to be established and maintained for a longer period (Čater and Čater, 2010). Of these four elements, knowledge transfer could play a significant role in enhancing the relationship and thus the level of mutual commitment and trust.

Relationship commitment can also be described as "*normative or instrumental*" (Zhao *et al.*, 2008). While Keiningham *et al.* (2015) list three types: normative, affective and calculative. Normative commitment is the deeper because: it entails "*mutual commitment and sharing*" and it relies on trust existing between the two parties, which is the catalyst for a long-lasting, positive relationship. On the other hand, instrumental relationship commitment is based on accepting the action of the other party where the relationship may be demolished as the action disappears. Although normative commitment appears to be critical, especially between similar national entities, instrumental commitment is also required if the business between developers and their customers is discontinued for a long time, because it can instantly resume in response to a need for a newly-developed product.

Commitment is often considered as a combination of affective, continuance, and normative commitment (Bansal, Irving and Shirley, 2002; Čater and Čater, 2010). Affective commitment is similar to loyalty (norm), whereas continuance commitment is a locked-in relationship in which the customer must stay, and normative commitment is a natural relationship, where the customer ought to be in this relationship. Additional factors include economic, forced, and habitual commitment (Keiningham *et al.*, 2015). In economic commitment, the customer recognises the accumulated benefits, whereas forced commitment occurs when the customer has no alternative, and habitual commitment occurs when the customer buys repeatedly from the same provider. National similarity might be considered as a form of locked-in commitment, when the national authorities direct, through the defence strategies, the local purchaser to buy from local suppliers, regardless of the quality of their product. In this case, national manufacturers must enhance their product quality to achieve effective commitment.

The author believes that AVM managements in the Gulf States with the full support of the national authority can prepare their strategies and resources to ensure the appropriate combination of different commitments depends on the relationship with their customers. According to Zhao *et al.* (2008), these types of practices are referred to what is known as relationship commitment. They define the relationship commitment as "*the willingness of a party to invest financial, physical or relationship-based resources in a relationship*". These efforts which stand on predefined strategies should lead AVMs in the Gulf States to capture customer satisfaction and fulfil the NDS requirements to approach the arm independence goal. In addition, for B2B relationships to be successful, personal interactions must be established to include similar functionalities in both the AVM and customer organisations. However, this type of interaction cannot exist if the enterprise management (organisational culture) does not encourage or at least plan for such close relationships within their organisation. Accordingly, it is important to form relationships among the enterprise's personnel, superior and subordinate (Ovblad and Bantekas, 2010). Such relationships, known as psychological contracts, can help engage individuals from the customers' organisation in an affective commitment that benefits all parties.

3.3.4 Summary

The relationship in B2B practices has a significant effect on customer satisfaction. This chapter considered the effect of major factors such as interaction, involvement, trust and commitment in enhancing B2B relationships and customer satisfaction. Relationships with military organisations are more challenging than civilian ones in terms of both confidentiality and culture, and great efforts are is required to establish and maintain the links that sustain business with them. The above sections (3.3) highlighted the problems associated with establishing interactions and relationships, which can be considered in terms of three elements (involvement, trust, and commitment). AVM managements must use interaction as a catalyst to achieve sufficient integration in the network in order to ultimately improve customer satisfaction.

3.4 Systems Engineering as an enabler to enhance customer satisfaction

3.4.1 Introduction

Thus far, this thesis has introduced management disciplines, such as strategic and supply chain management, which are essential for the success of AVMs in the Gulf States. It has also discussed how interactions among different entities sharing common interests can enhance the practice of these management disciplines to ensure customer satisfaction in a complex environment. The author has proposed that AVMs require a systems engineering (SE) approach to manage their resources effectively, because this "*integrates all the disciplines and specialty groups into a* *team effort forming a structured development process that proceeds from concept to production to operation* (Gräßler and Yang, 2016)*. Systems engineering considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs*,*"* as defined by the Council of Systems Engineering (Ryen, 2008). This discipline has been applied for 50 years as a unique approach that analyses and resolves issues related to complex systems by using the most applicable heuristic techniques (Honour, 2004). Akeel and Bell (2013) depict how this discipline is universal and can interfere and add values to different fields. They assert that "*systems engineering is distinct in consisting of a series of methods that in theory can be applied in almost any domain. It aims to integrate the outputs of conventional engineering disciplines such as mechanical, software, electrical, structural and so on, to deliver complex technical products. Systems engineering also addresses the needs of users and the management of engineering processes, and hence pays attention to some of the social elements of delivering complex technical systems*" (Akeel and Bell, 2013). Dahmann and Baldwin (2011) clarify that "*classic systems engineering processes focus on the system, taking user needs, translating these into system requirements and establishing system boundaries and interfaces based on an understanding of the users' needs*" which reflect the involvement of SE different tools to cover the entire development process. Indeed, there is a positive relationship between project success and the use of SE methods (Hillson, 2009). This relationship is strong because SE covers the entire system or project life-cycle, beginning with the exploration of customer needs and ending with system disposal (Ryen, 2008). Thus, the author demonstrates the importance of SE in providing essential tools that ensure that stakeholder's problems are resolved, with appropriate validation, and brings technical issues and managerial disciplines alongside business approaches to achieve the goals of the business and its customers simultaneously. SE therefore has the capacity to provide tools that can address both the organisational and technical challenges of AVMs in the Gulf States, helping to grow enterprises with strong integrated values that embrace customer satisfaction. If one wishes to discuss the SE as a discipline, then one should understand what it is.

A system can be defined as *"a construct or collection of different elements that together produce results not obtainable by the elements alone"* (Yasseri, 2014). This concept has evolved to think systematically in solving problems from a perspective or different perspectives (operational, functional, structural, etc.) as to watch the problem from the whole perspective and how its main constituents affect the whole (Kasser and Mackley, 2008). They argue that both, system engineering (analysis) and system thinking, "*have their place in developing an understanding of a system*" (Kasser and Mackley, 2008). Yasseri (2014) and Kasser and Mackley (2008) summarise the need to determine what the system is and how to use such a concept correctly to analyse and solve problems. For example, to apply the system thinking to the thesis case study, both the AVM and its products can be recognised as systems, each with its own subsystem, and each with its own relationship with other systems, which must be integrated in order to fulfil the overall tasks and goals. The elements of a system can take many forms, such as subsystem suppliers, military agencies, R&D institutes, and third-party accreditation groups in the production system, and the parts that are needed to build the product system. "*System Engineering (SE) is a both managerial and technical approach to manage big, complex and risky projects*" (Locatelli, Mancini and Ishimwe, 2014). Moreover, the production entity system (AVM) and product system (armoured vehicle) must be highly integrated to enable the former to produce the latter efficiently and effectively, which forms a complex phenomenon. SE tools and system thinking are therefore required to deal with the complexities of development phases and production milestones. In fact, SE provides the systematic processes and appropriate tools that are need to directly support the life-cycle management of any system (Ryen, 2008). Therefore, the author of this thesis has become more confident about adopting such a discipline in order to contribute towards enhancing the performance of the AVMs in the Gulf States.

3.4.2 The contribution of systems engineering

From the introduction above, one can understand that system engineering enables the providers' management to ensure the integration of parts from different sources, allowing them to operate together (technically) rather than alone, contributing to effective operation in accordance with the needs of customers. The key aspects of the production entity system (managerial integration) include (1) the understanding of customer needs, (2) the design of an appropriate system that achieves these needs by meeting customer specifications, (3) the systematic trade-off between various propositions to select one for development, defining essential plans for the development process, and (4) testing and validation, deployment, and follow-up through the system life-cycle for maintenance and upgrading. The system (product) development must be carefully managed, using tools and approaches wisely, based on technical, managerial and social capabilities, to achieve customer satisfaction. Indeed, SE is "*a superset of disciplines incorporating both engineering and management sciences*" (Haskins, 2008) offering tools and methods that can be used to build an optimised system (Yasseri, 2014). Figure 3-7 shows the elements of SE, including all managerial and technical aspects, which can be defined as enterprise processes, project/technical processes and agreement processes (Haskins, 2008):

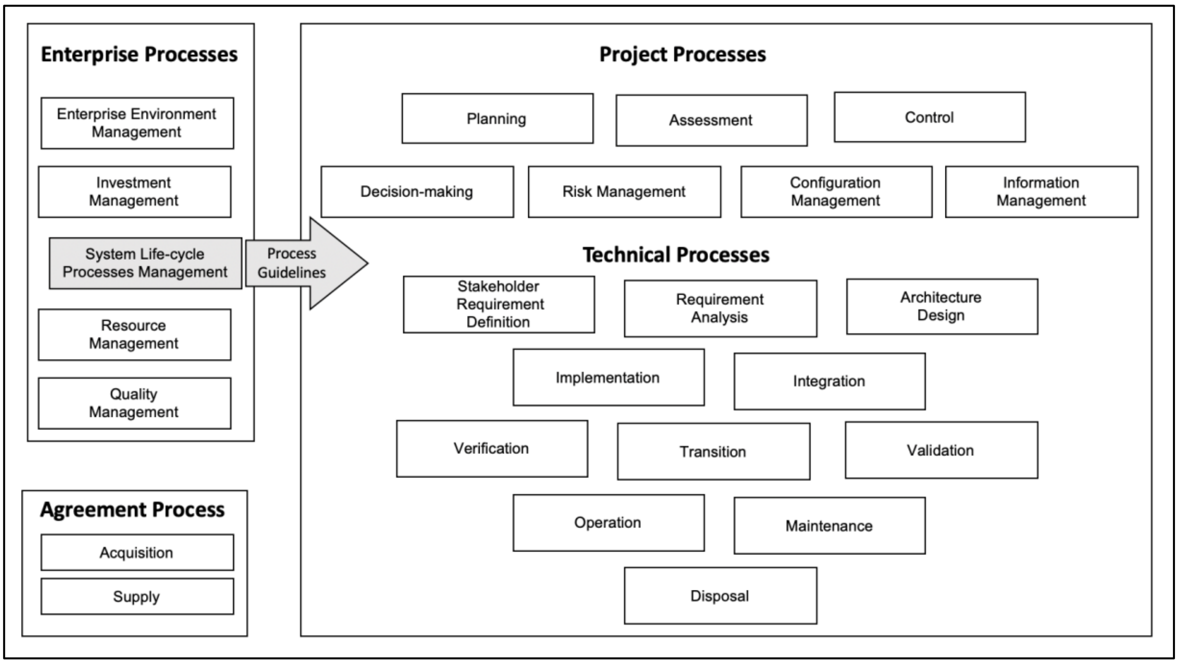

Figure 3-7. Systems engineering life-cycle processes (Haskins, 2008).

1. The enterprise processes highlight the managerial aspects of the enterprise that are needed to build a successful enterprise. These consist of strategic issues such as environmental and investment management, the acquisition and management of resources, and quality management.
2. The project/technical processes have an upper (managerial) aspect and a lower (operational) aspect. The upper elements are strongly related to the strategic issues of the enterprise process, which are necessary to produce good values using the lower elements.
3. The agreement processes concern the relationships between the developer and other entities such as subsystem providers, R&D institutes, T&E teams and third-parties.

Another contribution is the introduction of ISO/IEC 15288. Thomas (2007) remarks how (ISO/IEC 15288) illustrated the product life cycle (See Table 3-1) to show the strong connection between the system engineering and the success of product development. This figure demonstrates the development phases and militons when the decesions are taken. This force management and enterprise' owner to follow a systematic development process.

Haskins (2008) and Thomas (2007) through Figure 3-7 and Table 3-1 address all arrangements needed to develop the required values and controlled by one discipline - system engineering. As previously mentioned, the SE can deal with the strategic management issues, which is represented by the enterprise process and project process. The supply chain processes are described through the technical process and agreement process in which cooperation, coordination and collaboration aspects are required to reach sufficient interaction and integration. Furthermore, Haskins (2008) through the figure includes many prime tools such as quality management to monitor and enhance the development process. Indeed, in the development of new products, SE has the ability to unite different disciplines such as strategic management, marketing management, quality management, production management, human resources management, and supply chain management, to create the competences required in each managerial/technical discipline to enable enterprises like AVMs to achieve customer satisfaction.

Life Cycle Stage	Purpose	Decision Gates
Concept	• Identify stakeholder's needs • Explore concepts \ • Propose viable solutions	Decision Options: • Execute next stage • Continue this stage • Go to a preceding stage • Hold project activity • Terminate project
Development	• Refine system requirements • Create solution description • Build system • Verify and validate system	
Production	• Produce systems • Inspect and Test	
Utilisation	• Operate system to satisfy user's needs	
Support	• Provide sustained system capability	
Retirement	• Store, dispose of the system	

Table 3-1. System life-cycle as described by ISO/IEC 15288 (Thomas, 2007).

To cover such comprehensive requirements, Haskins (2008) introduces two important aspects: enterprise engineering and socio-technical systems, as an extension to SE practices. This is based on a five-level nested SE model in which systems science is applied to solve different types of problem, see Figure 3-8 (Simonette *et al.*, 2008) , and this thesis deals with the higher levels. The lower level deals with the product SE where the system is a technical product and SE is used to integrate the subparts effectively. The second lower level is the project SE in which the system is a project handled by management, including all aspects (managerial and technical) of the development, deployment and disposal processes, across the entire product life-cycle. Then, the business SE is applied in which the system is the business environment, thus more than one enterprise (subsystem providers, support entities, etc.) is involved in the success of the product and must cooperate aptly to achieve product assembly and distribution to reach all potential customers and ensure business sustainability. The fourth level is the supply chain SE in which the system is the supply chain, thus comprising entities and supplies such as raw materials as well as one or more products. The aim of supply chain SE is to ensure the efficiency and effectiveness of the integrated upstream and downstream components. Last level is the socio-economic SE where the system is the entire network, and broadens the role of management to accommodate external influences such as government policy, economic situations and corresponding regulations (societal impacts).

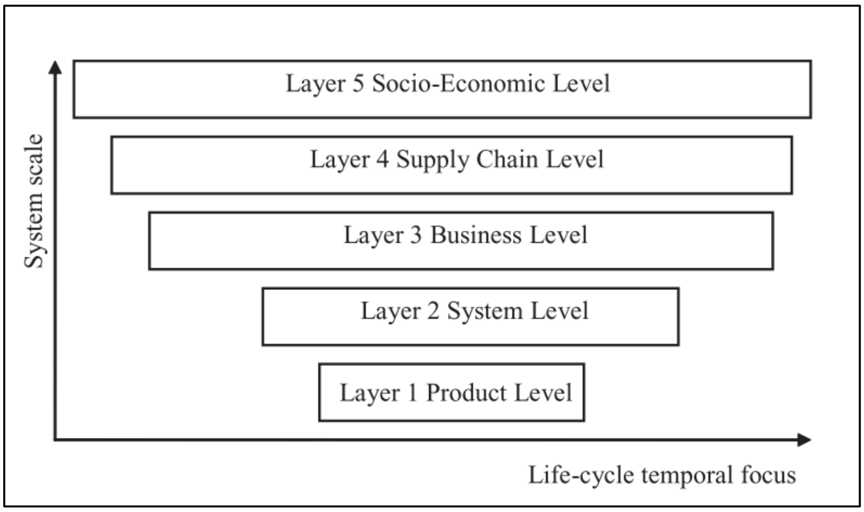

Figure 3-8. Five SE levels (Simonette et al., 2008).

These five layers clearly illustrate the situation of each enterprise (AVM), the surrounding environment and the capable players that influence the development process and customer satisfaction. The first level concerns how to assemble different subpart to work efficiently. To build such integrative values, developers follow the second level (project SE) to develop the product optimally. However, the second level requires select subsystem providers and support entities that have the ability and capability to offer the best parts and services (which has been discussed previously in this thesis). These different entities must be combined in a reliable network (supply chain SE) that ensures knowledge flows which benefits all involved parties to enhance their performances. Last, the network (socio-economic SE) must be controlled by a higher body, such as the national authority. This authority plays a significant role in guiding the entire network's constituents to fulfil the preassigned high-goals. Being in a network helps each enterprise within the network to reach its goal.

Thus, the previous paragraph indicates two essential players, AVM owner and national authority, that must manage their lower grade subsystems. For example, AVM's owner manages organisational different functionalities and national authority manages different industries. SE can work effectively in AVMs if the factors are understood and controlled by the management. It is therefore necessary that "*system requirements are relatively well established, technologies are mature, the system is being developed for a single or relatively homogeneous user community, and a single individual has management and funding authority over the program*"

(MITRE, 2014). Moreover, national authorities can play a significant role in controlling the relationships among stakeholders (other entities supporting the AVMs) and providing the tools needed to define customer requirements, evaluate alternatives, analyse feasible solutions, and select appropriate developers (MITRE, 2014). This ensures that a higher strategy is developed to create homogeneity among various systems, i.e. a reliable network or what is known by system of systems (SoS). The next section will describe different SE models that AVM management can apply to ensure project success while SoS will be discussed in section 3.5.

3.4.3 Systems engineering models

Many enterprises use repetitive SE models and standards in their daily practices, and AVMs must do the same. "*The benefits of adopting this model are: (1) to reduce technology and supply risks; (2) to reduce the opportunistic behaviour of suppliers; (3) to improve supplier commitment and performance*" (Locatelli, Mancini and Ishimwe, 2014). A SE model can be defined as "*a systematic approach to engineering or reengineering a system, incorporating best practices that have evolved during the second half of the twentieth century*" (Chang and Perng, 2008) Three such models are considered below:

1. The *waterfall model* (Figure 3-9) consists of 5–8 phases, each of which must be completed and checked before proceeding to the next stage. If a deficiency occurs during one stage, the activities are repeated until the deficiency is corrected. This model is used in development process that management must review and approve after execution. Locatelli *et al.* (2014) advice to use such model "*on small and not complex projects. It presents many limits on project risk management. It has more managerial prospective than technical*".

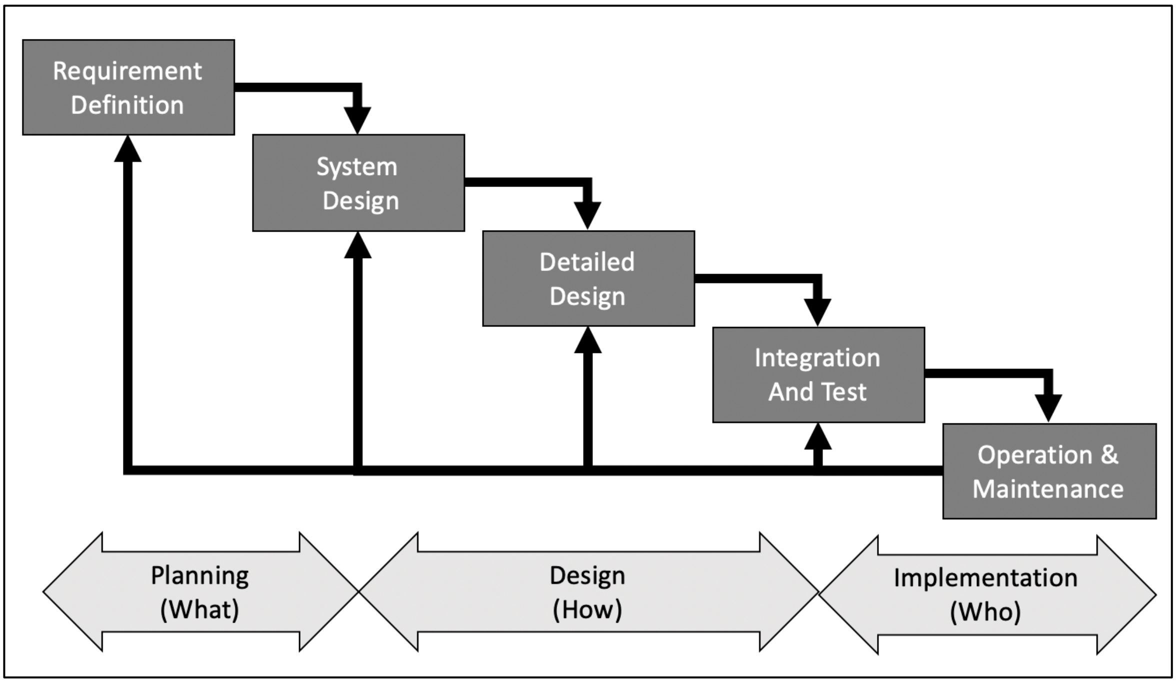

Figure 3-9. The waterfall model of the system life-cycle, adopted from (Bkcase, 2015).

2. The *spiral process model* (Figure 3-10) is similar to the waterfall model, but instead of repeating a single stage all preceding stages must be repeated once a deficiency is discovered. This is considered "*a risk-driven approach*" because it imposes the necessary risk analysis after each of the three prototype phases and tries to mitigate risks before the next stage commences. This model allows management to continuously plan for the next step even when challenged with unexpected events. This model is efficient for complex projects (Locatelli, Mancini and Ishimwe, 2014).

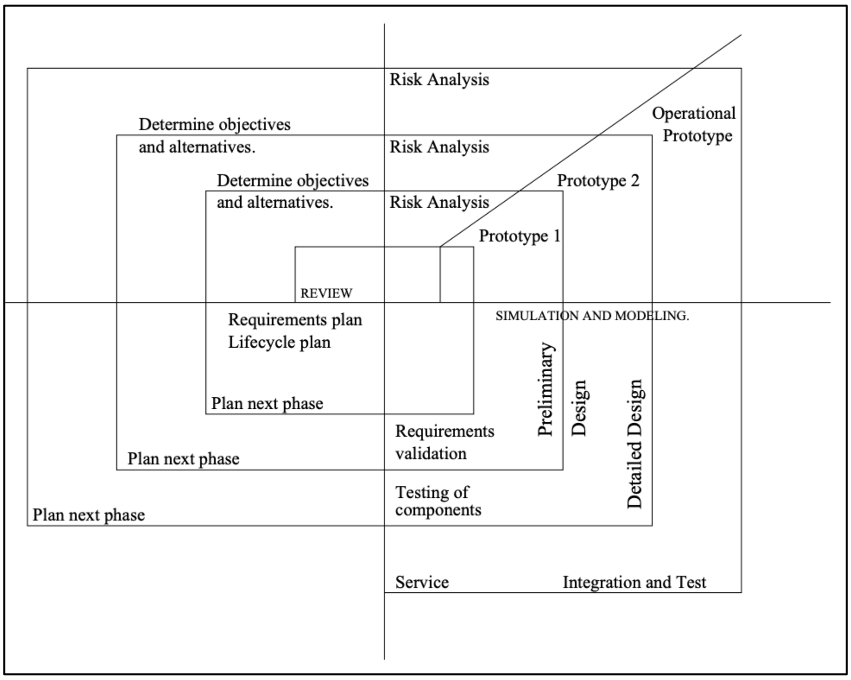

Figure 3-10. The spiral process model of the system life-cycle (Locatelli, Mancini and Ishimwe, 2014).

3. The *V-process model* (Figure 3-11) is shaped like the letter V, starting from the top left and proceeding through the base to integrated system verification process at the top right. The key aspect of this model is testing the system against each design step, which includes the system and subsystems. This synchronisation requires a robust AVM business strategy, the selection of appropriate subsystem suppliers and qualified resources.

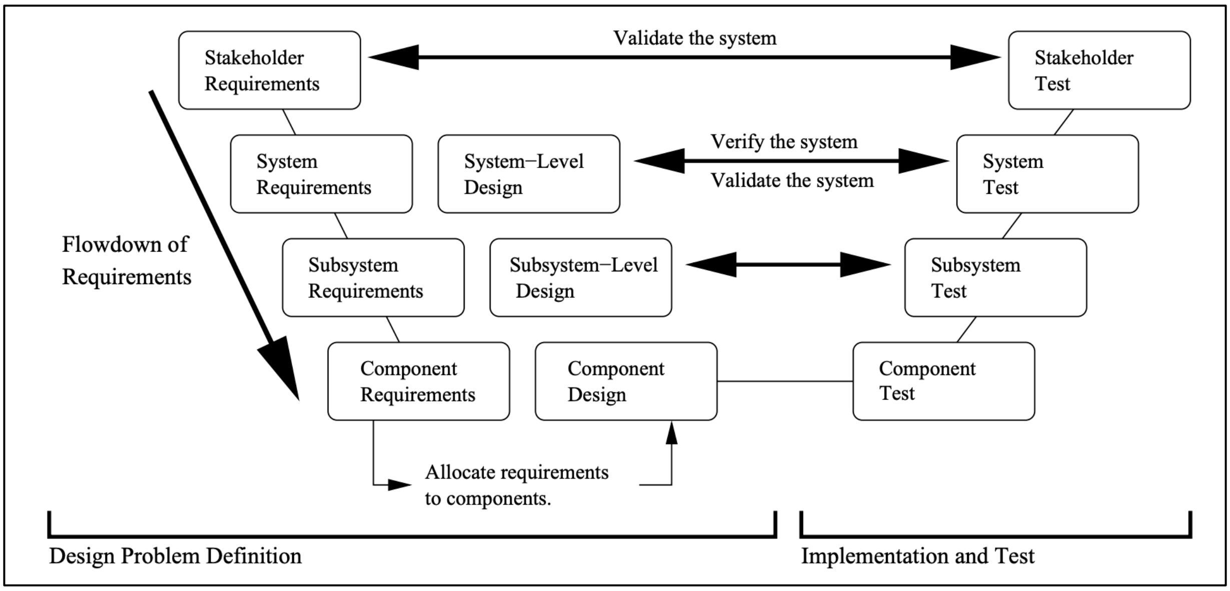

Figure 3-11. The V-process model of the system life-cycle (Vaneman, 2016).

Thomas (2007) states that these models are essential for discovering and remedying unpredictable deficiencies early in the development process using an iterative approach. He also proposes the "*ISO/IEC 15288 Systems engineering-System life cycle processes*" as a common framework dedicated to the entire systems life-cycle, including 25 management and technical processes (Figure 3-7) (Thomas, 2007). It is recognised that the inclusion of such a model and previous three models enables the decision-maker to discuss every process separately and recognise the links between them to ensure their integration in pursuit of customer satisfaction.

Another beneficial model is the PADOV model (Yoon and Byun, 2012), According to them this model comprises of five development stages: plan the technical efforts (P), analyse the requirements (A), define the candidate architecture (D), optimise the options (O), and verify the system (V). The relationship between PADOV and SE is shown in Table 3-2.

SE categories	P	A	D	O	V
Conceptualizing problem and alternative solutions	×	×	×		
Mission/purpose definition	×				
Requirements engineering		×			
Systems architecting		×	×		
System implementation					×
Technical analysis			×	×	
Technical management/ leadership	×	×	×	×	×
Scope management			×	×	
Verification/validation					×

Table 3-2. Systems engineering categories and PADOV (Yoon and Byun, 2012).

These models are essential at different stages. For example, the waterfall model is used "*through a series of phases/milestones in a linear fashion, with the first phase dedicated to the requirements task*" (MITRE, 2014). The PADOV models are suitable at the design stage, the spiral process may be used to manage project risks in different development process (Unger and Eppinger, 2011), and the V-process model may be ideal for the entire development process especially for verification and validation purposes (Guey-Shin Chang, Horng-Linn Perng, 2008). Finally, the comprehensive ISO/IEC 15288 model covers all managerial and technical aspects and integrates them to fulfil the goals of AMMs (Figure 3-12). These SE tools are limited to individual systems, although they can be applied to systems that interact with similar systems in a dynamic environment. To look at more complex interactions, *system of systems* methods are required as discussed in more detail below.

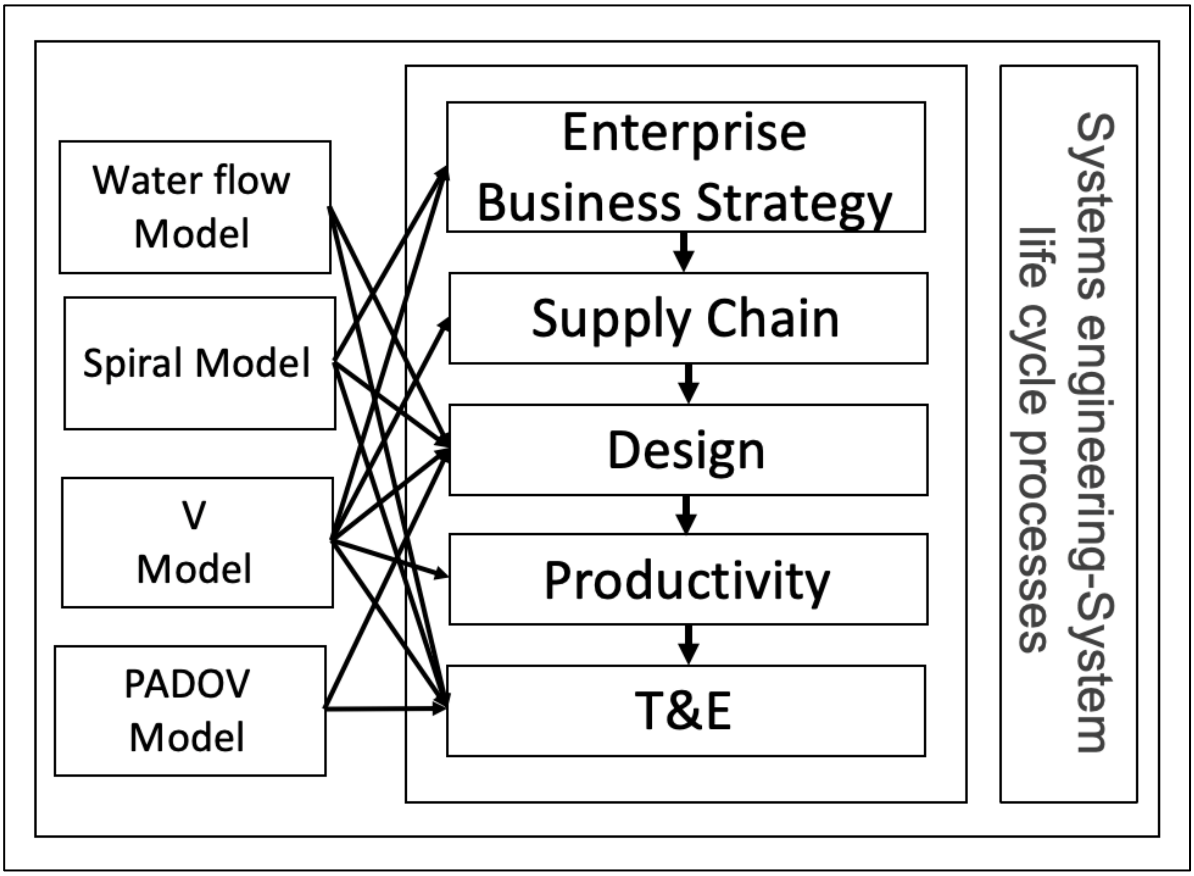

Figure 3-12. An integrated systems model used in the context of AVM management (Author).

3.5 The system of systems concept

In this thesis, AVMs in their dynamic surrounding environment are treated as an evolving system in a system of systems (SoS) assembly or network. As different systems are developed and begin working together, they need certain media (network) as enablers to integrate the systems and achieve both individual and common (network) goals (Lane, 2013). This type of arrangement (Figure 3-12) brings the independent systems together to interact, collaborate and evolve their capabilities to approach a pre-defined goal. The SoS concept is therefore an extension of the discipline of SE.

The SoS concept can overcome some of the deficiencies of SE (Keating, Padilla and Adams, 2008) including holism, complementarity, pluralism, expectation, emergence, incompetence, boundaries, metasystems and context dominance, which are briefly explained in Table 3-3. According to SoS concept, AVMs must understand how to interact with other systems to form a SoS in order to address these deficiencies. For example, emergence is a key attribute that allows AVMs to oppose the dynamic environment.

SoSE Area	Requirements Implication
Holism	Requirements for the SoS may be incompressible—they may not be capable of being reduced via hierarchical relationships.
Complementarity	Multiple perspectives of the SoS may be incompatible and may not easily translate into a definitive set of requirements.
Pluralist Expectations	There may exist widely divergent, potentially tacit, expectations with respect to the purpose and nature of the SoS—potentially beyond requirements capture and reconciliation.
Emergence	The SoS may exist in an unstable environment and be subject to emergent behavioral, structural, and interpretation patterns that cannot be known in advance and lie beyond the ability of requirements to effectively capture or maintain.
Incompleteness	Our understanding of a complex SoS can never be complete and is always fallible. This translates to requirements always being incomplete and potentially inadequate.
Boundaries	The boundaries and boundary criteria for complex SoSs are dynamic and must evolve with new understanding—this will impact requirements at the SoS and constituent levels.
Metasystem	The integration of multiple systems within an SoS is managed through the structural requirements of the metasystem. The metasystem is subject to its own requirements.
Context Dominance	The more complex an SoS, the higher the potential to experience "soft" (e.g. political) influences that lie beyond traditional requirements concerns or capture.

Table 3-3. SoS attributes that complement SE (Keating, Padilla and Adams, 2008).

Although many authors claim that SE and SoS are distinct, the relationship between them (no matter how weak) must be understood because SE alone would in most cases be unsuccessful (Keating, Padilla and Adams, 2008). Such a relationship can be described as follows: "*The design, deployment, operation, and transformation of metasystems that must function as an integrated complex system to produce desirable results. These metasystems are themselves comprised of multiple autonomous embedded complex systems that can be diverse in technology, context,* *operation, geography, and conceptual frame"* (Keating, Padilla and Adams, 2008). This concept is summarised in Figure 3-13*.*

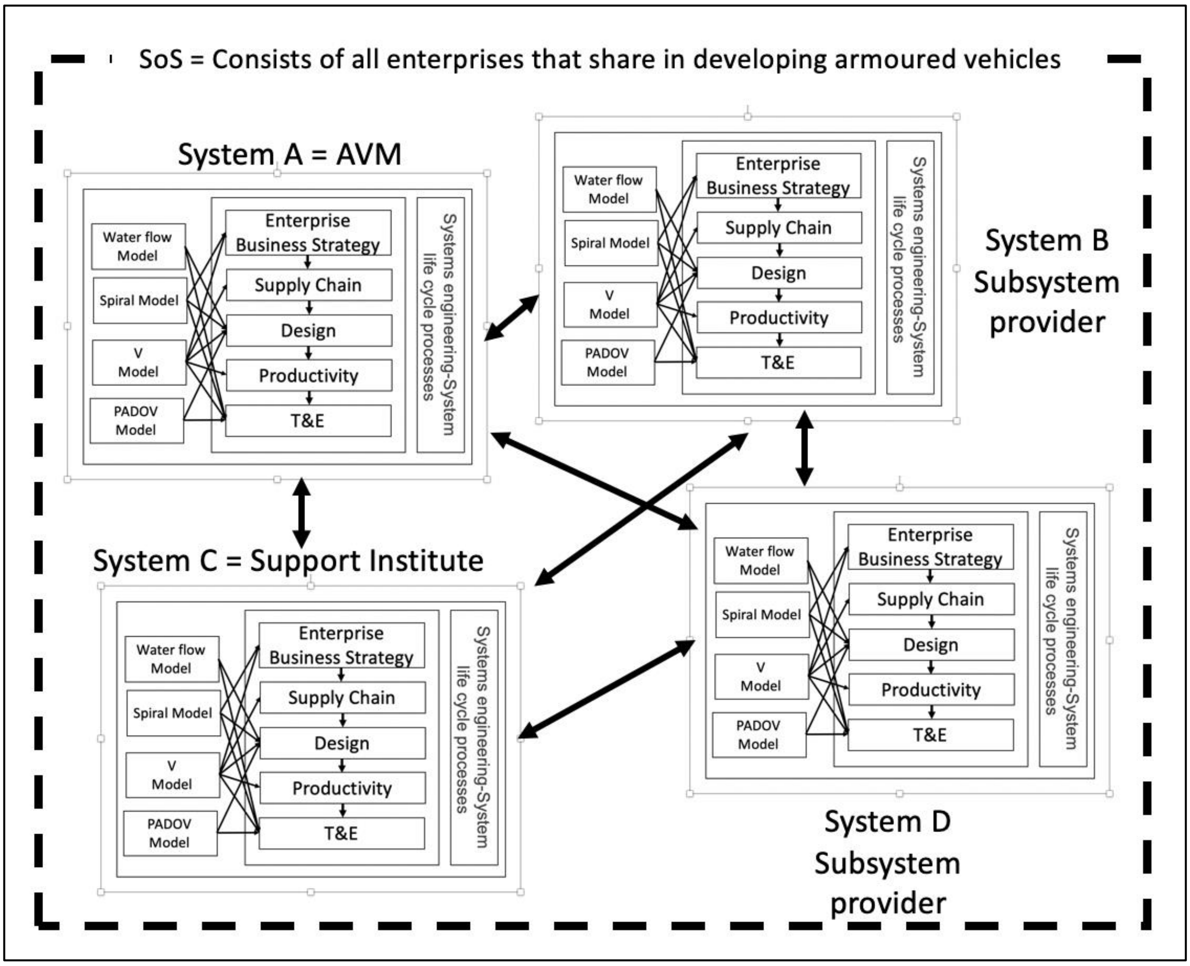

Figure 3-13. The system of systems concept (Author).

To achieve significant integration, AVMs (as a system) must be formed under a defined architecture that organises their resources (subsystems) and allocates responsibilities, enabling them to interact with stakeholders. AVMs must also cooperate with other manufacturers for certain purposes, and must remain flexible (agile) to ensure they retain the ability to adjust their resources to cope with unexpected changes in the environment. Thus, AVMs must exist within a network that receives the output of other systems to produce values that satisfy their customers. A system located in a dynamic environment alongside other systems with continuous and diverse interactions becomes more complex, and traditional SE is no longer sufficient to deal with this complexity. The dynamic environment plays a significant role in shifting the approach from a static system, which can be disassembled for top-down analysis, to independent systems that evolve and change behaviour as new situations arise, using different interactions with other systems to reach mutually beneficial goals (Alfieri *et al.*, 2013).

To clarify this, SoS has been defined as: *"A set or arrangement of systems that results when independent and useful systems are integrated into a larger system that delivers unique capabilities. SoS are acknowledged as a significant engineering challenge due to high complexity. The main engineering and management challenge for defence organisations in relation to SoS is how to effectively integrate, manage, evolve and operate multiple interdependent heterogeneous systems and capabilities"* (Chen and Unewisse, 2017). Similarly, Keating (2008) describes SoS as a discipline that (1) integrates various independent systems to form a higher-level metasystem that performs a specific purpose, (2) enables the constituent subsystems to perform with a better capacity than alone, (3) allows each subsystem to operate autonomously in order to naturally adapt itself to the higher-level of SoS; and (4) acquires resources with emergent (dynamic) behaviour to deal with complex systems. By increasing the global environment's complexity, the enterprise (as a system) aspires to become part of an SoS (network). This helps such enterprises to deal more efficiently with emergent behaviour, rapid changes in circumstances, and continuous customer claims for improved quality and up-to-date values, which are difficult to manage using conventional methods (Boehm *et al.*, 2012). These definitions express that the SoS concept rests on three facts: first, all systems (including AVMs) are sufficiently independent and heterogeneous that significant effort is required to achieve integration that enables these distinct systems to act as a single system and fulfil the intended goals. Second, all interdependent systems operate in a dynamic context, and complexity arises from such interactions, which managements must take into account. Third, a complement to both the engineering and managerial aspects must be sought.

Furthermore, Lane (2013) defines four types of SoS with regard to managerial practices. The first one is the virtual type where the SoS has clear objectives but lacks a central control. The systems that constitute the SoS are not necessarily known. The second type is the collaborative type where the constituent systems voluntarily work together to reach a specific central goal (known to all). Where the Acknowledged type, the third type, considers each system that works autonomously with "*recognised objectives, a designated manager, and resources at the SoS level"* to accomplish specific common goals that benefit all of the systems. None of the individual systems has overall control of the SoS but each system controls its interactions with other systems. The last type is the directed as the SoS centrally managed by one authority (e.g. the government) with pre-assigned goals. However, each system within the SoS may operate independently, especially in the case of evolutionary situations. In this context, it appears that most AVMs are part of an acknowledged SoS, but in some cases they can participate in a directed SoS if the government or military authority regulate the industry to fulfil specific goals such as autarky in a cooperative manner.

However, Dahmann (2015) emphasises some areas that require attention when applying the SoS concept. First, each SoS constituent system (AVM) has its own stakeholders, including its owner, customers and different support entities, and a unique business process, organisational structure and development approach. These aspects require a single authority (such as a military authority) to control the entire SoS (industry local network) more effectively, to achieve better integration, coordination and cooperation and hence fulfil collective objectives (autarky). The nature of the SoS may therefore fluctuate between the acknowledged directed types. Second, the lack of a single authority (military authority with an NDS) increases the burden on each enterprise (AVM) management team to lead their organisations in a highly dynamic environment. It is challenging for the AVM management team to manage their relationship with different entities. Third, the development of each constituent system must be coordinated with the development of the entire SoS. However, the SoS forces the constituent system (AVM) to develop most of the time, otherwise it will secede from the SoS or require more resources to maintain its position. Any deficiency in the elements of one system (e.g. subsystem provider) could therefore affect the development of the entire SoS. Fourth, the requirements of each system (AVM) may not match those of the SoS (network). Each constituent system (AVM) tries to match its capabilities according to customer requirements, so understanding each system’s requirements and capabilities as well as those of the entire SoS is essential for network success. Fifth, autonomy, interdependence and emergence among the constituent systems will increase the complexity of the SoS. However, efficient interactions (involvement, trust, and commitment) increase coherence and reduce complexity. Six, the SoS must have objectives (producing values that satisfy customers and approach autarky) and metrics for T&E. The latter requires funding and clear directions from military authorities, but diverse systems lead to complex T&E processes, which require detailed information and continuous learning through practice and experience. And last, the use of systems thinking should be expanded to include more SoS principles.

3.6 SE, SoS and systems thinking tools

The critical challenges that face enterprises include the integration of technical and management aspects, which is why SoS and SE concepts "*effectively integrate, manage, evolve and operate multiple interdependent heterogeneous systems and capabilities*" (Chen and Unewisse, 2017). Likewise, to address the problem and seek a solution, systems thinking offers a "*powerful perspective, a specialised language, and a set of tools"* that help managements and researchers to understand the complex issues raised by the numerous interrelationships and nonlinear interdependences. They use the term "*wicked problem*", where the SoS concept indicates that "*everything seems to connect to or entangle with others*". Accordingly, the systems thinking technique is recommended in order to understand the messiness of SoS problem space, which involves worldviews of various "*interdependent SoS throughout their lifecycles*" (Chen and Unewisse, 2017). Therefore, the author finds that dealing with AVMs in the Gulf States is a problem that requires system thinking techniques.

There are four ways to deal with SoS problems by applying appropriate systems thinking methods (Kasser and Mackley, 2008). Firstly, solving the problem and ignoring the possibility of problems automatically getting solved or disappearing without interference. Secondly, resolving the problem which is trying to remove the problem by appropriate actions, which require adequate experience. Thirdly, optimising the solution which involves reaching a solution via experiments. Lastly, dissolving the problem which involves redesigning the system and/or changing the perspective to seek a better solution or innovation. The fourth approach (dissolving the problem) describes the role of systems thinking in solving an enterprise's problems (Kasser and Mackley, 2008). This involves being open to innovation, which requires competency, critical knowledge, and significant collaboration, coordination and communications with stakeholders, especially the subsystem providers and customers. The author prefers to adopt the third and fourth solutions that including the perspectives (worldview) of stakeholders which can enhance such problem-solving approaches. Also, the author selects the soft system methodology and learning cycle as two beneficial approaches to enhancing gradually the situation of AVMs in the Gulf States and thus reaching the preassigned national goals. The two approaches will be explored in more detail in the next two sections.

3.6.1 The SoS and soft systems methodology

The SoS concept has been used to address many problems involving the defence industries and the performance of AVM in the Gulf States. For example, soft systems methodology (SSM) is a seven-stage method (Checkland and John, 2010) that was used by the Australian defence authorities to create a tool for continuous learning, by engaging stakeholders and exploiting their knowledge, thus helping the defence industry to achieve their goals (Hodge and Cook, 2013). Therefore, the author of this thesis will add the learning cycle into the SSM. Because the SSM is an iterative approach to tackle existing organisational situations by introducing new concepts and ideas (Checkland and John, 2010), it leads to producing continuous learning cycles. It is a soft systems methodology because it introduces suggestions (world-views) and allows managements to perform only necessary changes where the final aims will be reached after a while. In contrast to the hard systems methodology, which recommends a complete set of solutions. SSM considers the following circumstances (Checkland and John, 2010). Firstly, SSM organises all "*perceived problematical (social) situations*" and thinking about the actions that will improve the situation. Secondly, the different interacting perceptions from different people leads to greater complexity. Thirdly, people with different perceptions (conflicting worldviews) try "*to act purposefully with intention*". Fourthly, conflicting worldviews and purposeful actions lead managements to seek an "*action to improve*" provided by the SSM approach through "*social learning*". Hence, it can be noticed that the SSM approach allows the management to improve its performance while receiving suggestions from different points of view.

Checkland and John (2010) argue that the SSM framework has become sufficiently mature to supersede the SE framework: "*Having introduced the notion of 'worldview' – essential in dealing with human social complexity – we were thereafter thinking of* *systems models not as descriptions of something in the real world but simply as devices (based on worldview) to organise a debate about 'change to bring about improvement'. That was the key step in finding our way to SSM".* Therefore, this framework recommends considering all points of view to suggest comprehensive improvements which form a new situation, which is exposed to further change in an endless, iterative process, to construct the learning cycle which will discussed in the next section.

The seven stages of the SSM are considered in greater detail in the discussion chapter to compare this methodology with the thesis conceptual model to prove that the latter is more convenient for SMEs. The seven-stages SSM are summarised below (Burge, 2015) and illustrated in Figure 3-14:

1. Define a situation considered problematic
2. Capture the rich picture of various perceptions that describe the real problem
3. Formulate root definitions of relevant systems of purposeful behaviour
4. Form conceptual models including human activity systems
5. Compare the conceptual models with the real-world transactions
6. Define changes that are both desirable and feasible
7. Take action to enhance the problematic situation.

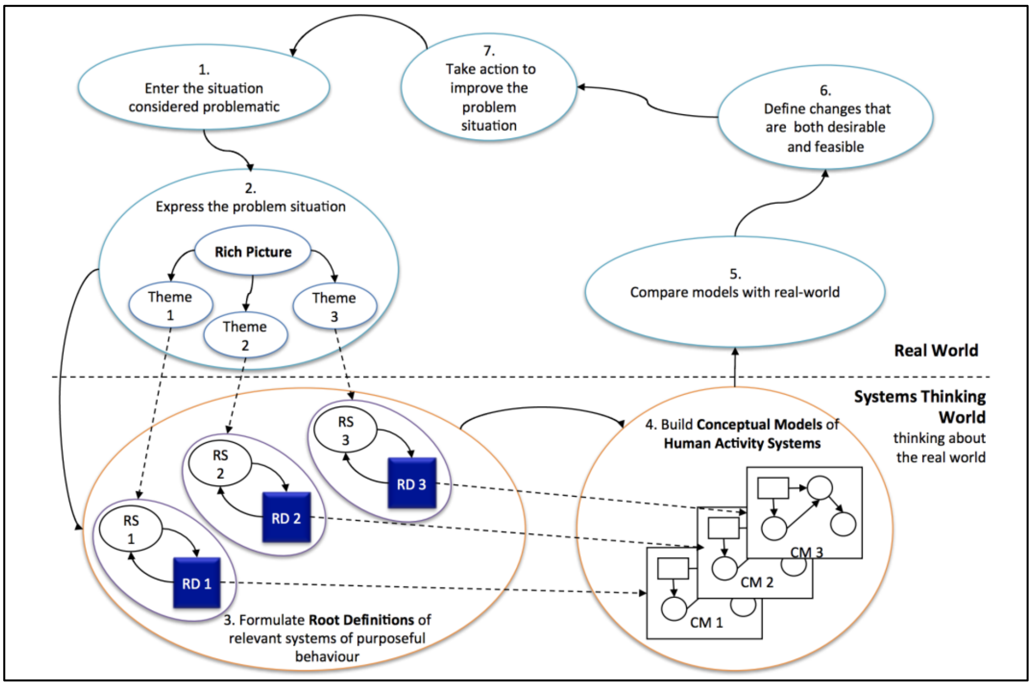

Figure 3-14. The seven stages of Checkland's soft systems methodology (Burge, 2015).

3.6.2 SoS and the learning cycle

Rodríguez-Ulloa *et al.* (2011) relate the outcome of the system dynamic to the learning cycle as a "*problem-oriented understanding of the problem situation*". Checkland and John (2010) linked the SSM to the learning cycle as the former was used to define the existing problem to activate the latter. Similarly, Barton (2014) introduced a systems methodology that consists of four learning cycles (Figure 3-15) including the definition cycle, the model validation cycle, the policy testing cycle, and the continuous improvement cycle. The first cycle is the most important learning cycle, which defines the strategies and activities required to approach them. This cycle may include developing the appropriate strategies (NDS and business strategies) to cope with the dynamic external and internal environments. The evolution of these strategies involves changing current activities, for example to achieve a reliable supply chain. The Model validation cycle includes the building of detailed activities that must be modelled and validated. The cycle has no end as long as the supply chain elements (process and resources) are elevated to achieve and retain a competitive advantage. The output of this cycle is a supply chain model (organisational structure, competent capital and human resources, and capabilities) supported by various reliable external intellectual (R&D and T&E) and physical sources (subsystem suppliers). While the policy testing cycle aims to regularly test the model against changing external and internal environments, leading to new arrangements of the supply chain. The learning cycle is concluded by the continuous improvement where the new supply chain must be implemented with the defined changes along with monitoring and evaluation of the results, compared to the proposed strategy.

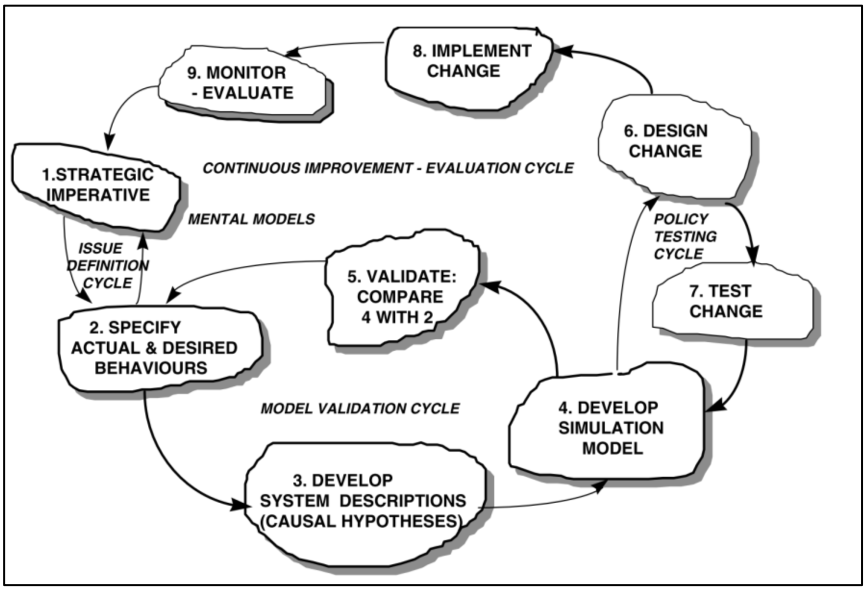

Figure 3-15. A systems methodology involving four learning cycles (Barton, 2014).

The learning cycle helps AVM managements to improve their resources based on changes of the dynamic environment. The outcome of the SSM can be fed into one of the four cycles depending on where the improvement must be done, i.e. in the strategy, preparing resources, evaluating resources, or evaluating the performance. The author believes that such learning cycle should always be attached to the SSM.

3.7 Conceptual Model Framework

The literature review (chapter 2 and chapter 3, sections 3-1 to 3-7) presented many facts that will enable AVM management teams to achieve customer satisfaction by developing values that approach the customers' needs. The development process was traced, from capturing the customers' needs to product deployment, including the stages of publishing a national defence strategy, setting an appropriate business strategy, and designing supply chain including the design phase, the production phase, T&E. These phases involve strategic, supply chain and customer satisfaction aspects. Moreover, the literature review described management practices in each phase which enable the management team to optimise the necessary technical elements. For example, the design phase involves the collection of customer needs and their conversion to requirements and specifications, which may be purely considered as a purely technical issue. However, managerial input is required to execute this process efficiently and effectively. Another example is T&E, which is usually considered a technical issue without a managerial aspect. This tests a product using a predetermined process and then evaluates the results using appropriate tools. Both product design, production and T&E are critical phases that significantly affect the development process in terms of costs and time. These phases, along with the other phases must therefore be tightly controlled by the management team.

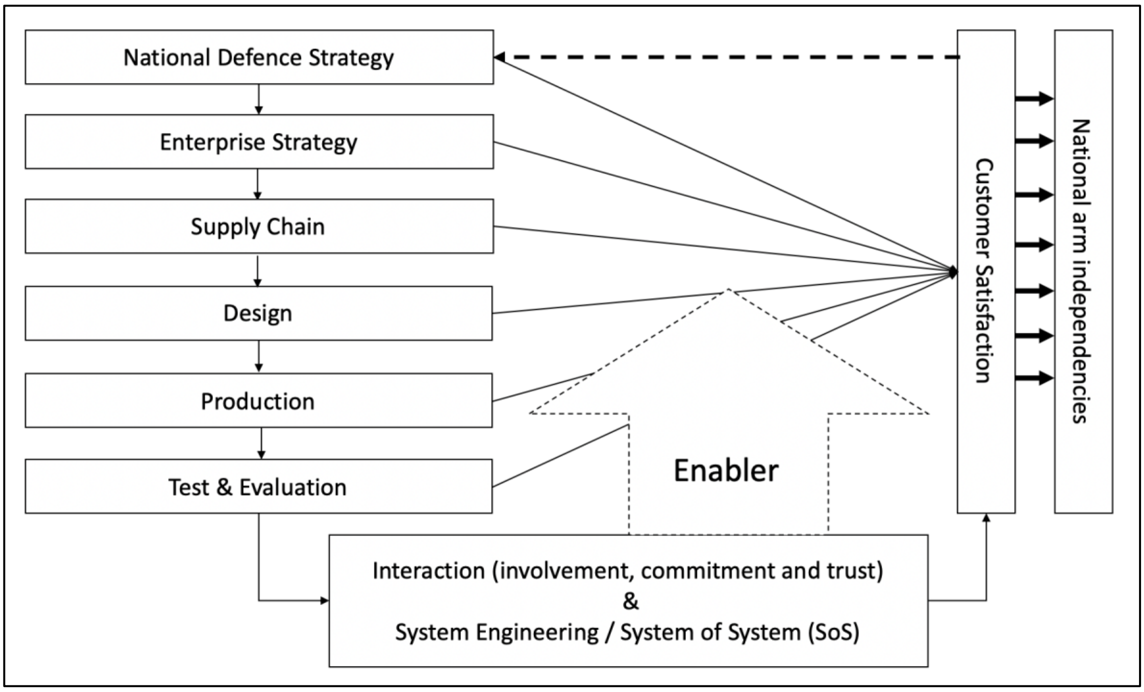

Figure 3-16. initial conceptual model (Author).

The literature review indicated the prime elements which ensure customer satisfaction in the B2B relationship. These elements were elaborated under the three topics: involvement, commitment and trust. These three topics help the two organisations in the B2B relationship to achieve better integration among different individuals and subsystem parts to create high-quality products. The author proposed that customer satisfaction is one of the indices that mark the successful development of products. The abovementioned ideas will now be built into a conceptual model framework.

Finally, the discipline of SE, discussed from 3-3 to 3-7, has introduced many tools and models (Figure 3-13) that (1) integrate technical and managerial aspects to achieve technical practices efficiently and effectively by using appropriate managerial practices, (2) enable the management of different technical practices by applying systems thinking to solve existing problems, and (3) deal with continuously evolving environments that require continuous monitoring and changes within the enterprises. The B2B and the SE were considered as enablers to enhance the managerial tools (strategy and supply chain)

This framework is the conclusion of the literature review and it illustrates the situation of any enterprise (AVMs in our case) in the dynamic environment, and based on the literature review there is a gap between current applications and contemporary efforts to ensure better performance. The conceptual model framework consists of four concentric circles, surrounded by the dynamic environment (the outermost circle). The second outermost circle is these parties that affect the AVM under the changes happen in the outermost circle (the dynamic environment). This circle also includes the customers (users) who raise their needs, which are included in defence strategy documents. The customer (military organisation) and the defence strategies are adjacent to each other in order to show that the former prepares and publishes the latter to fulfil their needs. The next innermost circle reflects the essential elements of AVMs which are needed to manufacture products with values that match customer requirements, such as developing a business strategy, creating a reliable supply chain that includes the actual development functions (design, production process and T&E) which must be fed by reliable, flexible and resilient resources. These prime functions require a combination of technical and managerial efforts based on the SE concept to accomplish them efficiently and effectively (Figure 3-17). The second innermost circle depicts the most critical elements which lead to having reliable interactions among all stakeholders that enhance the supply chain in the adjacent outer circle. The innermost circle reflects the evolving condition that affects all surrounding circles. The objective of the framework is customer satisfaction which can be a result of any development in each element available in the conceptual model. The optimum customer satisfaction can be reached by improving all elements.

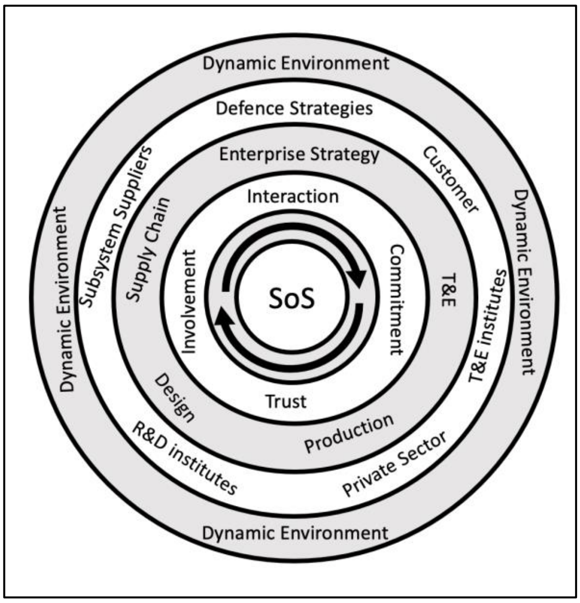

Figure 3-17. Conceptual model framework (Author).

4 Research Methodology

4.1 Introduction

This thesis considers a national defence issue that should be investigated to benefit the security of the Gulf States (by enhancing the performance of AVMs as part of the broader defence industry). Investigating this critical issue involves many limitations associated with the collection of data from both military organisations and defence manufacturers. Such organisations are usually reluctant to reveal their outputs and operations to the public. Moreover, defence industry issues are rarely discussed in the literature, although the industry relies on conventional civilian best practices to provide state-of-the-art values. Given these special criteria, a rigorous analysis of the literature covering familiar managerial strategies is needed to explore what is happening within these closed entities. In addition, the research described in this thesis uses SE, as discussed in the literature review, as an approach to deal with AVMs that operate in the dynamic environment in the Gulf States.

The research described in this thesis concentrates on one specific objective: increasing customer satisfaction by introducing the best products in the sense of quality, cost and lead time. To enhance these three dimensions, enterprise management should use many disciplines and tools (managerial and technical) in integrative way to optimise using their resources. In reality, the diverse managerial strategies that are used to control technical aspects generate multiple issues involving conflicts between different worldviews. These differing opinions, held by individuals from various organisations with different goals, different management levels and different skills, reflect cumulative experience which can be verified by the contemporary literature and my personal experience, leading to the objectives of this thesis. For example, this research combines recognised experiences from different organisations that work together towards defined objectives, although each organisation has its own goal. These experiences may be confirmed or refuted by the literature, and in the latter case this may lead to a new model that benefits AVMs in the Gulf States. By combining detailed experience and contemporary theories from the literature, hypotheses can be proposed that must be justified by further investigation and interpretation.

Figure 4-1 indicates the research strategy followed in this thesis. The author's personal experience combined with information provided by relevant individuals has played a significant role in steering the research by dictating the hypothesis and the appropriate approaches to address it.

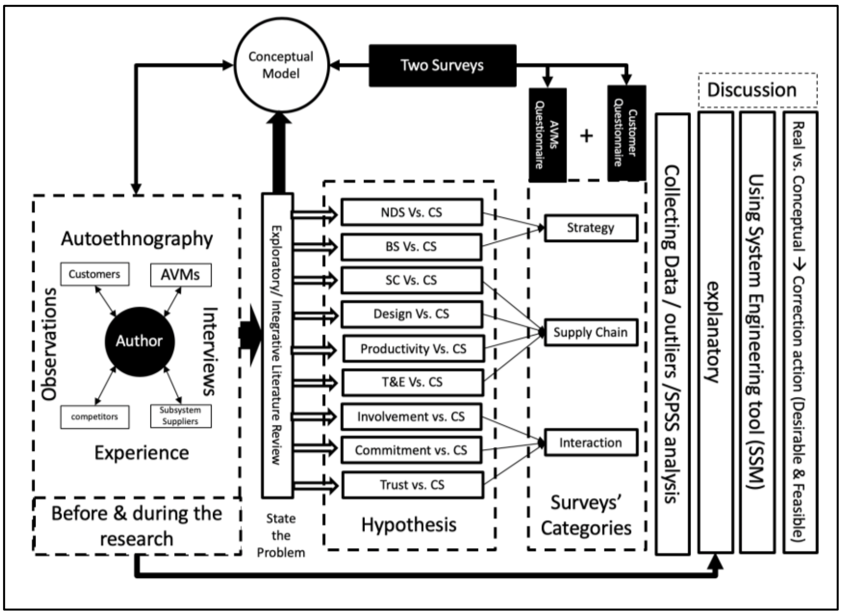

Figure 4-1. Research strategy and progress (Author).

The author has therefore divided the research into the key aspects listed in Table 4-1, where the output titles describe the contribution of this research to the performance of the defence industry.

Aspect	Topic	output	Output Title
1	Strategy	1	The importance of the NDS in establishing, controlling and maintaining the national defence industry as a vital approach to independence
		2	The influence of the NDS in creating a decent enterprise business strategy
		3	The contribution of the business strategy to enhancing customer satisfaction
2	Supply Chain	4	The influence of the business strategy in establishing a credible industrial network (locally and internationally)
		5	Factors that are essential to create a decent supply chain in a dynamic environment
		6	How the design phase can enhance the supply chain, product features and customer satisfaction
		7	Factors that lead to the acquisition of values that fulfil the customers' needs
		8	The influence of applying total quality tools in the design phase
		9	The impact of involving all concerned parties in the design phase
		10	T&E roles in developing new products: what are the main constraints in doing so?
3	Interaction	11	The interaction pillars in B2B that enhance customer satisfaction
4	System Engineering	12	Using SE to enhance customer satisfaction by improving the strategy and supply chain in AVMs

Table 4-1. The research aspects and topics discussed in this thesis (Author).

4.2 Research methods and approaches

Figure 4-1 provides a comprehensive overview of the methods used to communicate with the most important subjects during the research timeframe. These efforts must cover all perspectives, so the author adopted two primary positions (customers and AVM personnel) in order to comprehensively understand each perspective in terms of the issues listed in Table 4-1 and their potential solutions. Subsections 4.2.1–4.2.8 describe the methods used to explore these perspectives.

4.2.1 Personal experience in the field of the research

The author's personal experience as a stakeholder midway between military users and AVMs (system providers) led to the formulation of several critical issues that are considered in this thesis. These issues must be solved to enhance the acquisition process and benefit both customers (values that better fulfil their needs) and manufacturers (greater market sustainability). The issues are not limited to the relationship between the customer and AVM, but include other parties such as national military authorities that control the national defence industry and its customers. On the other side of the problem, subsystem suppliers contribute to the complexity of the issues, especially international suppliers that may be affected by emerging political factors. In Figure 4-2, the dashed circle represents the dynamic environment that affects the AVMs, which can be seen as part of a SoS, hence the need to use SE tools to address the research hypothesis.

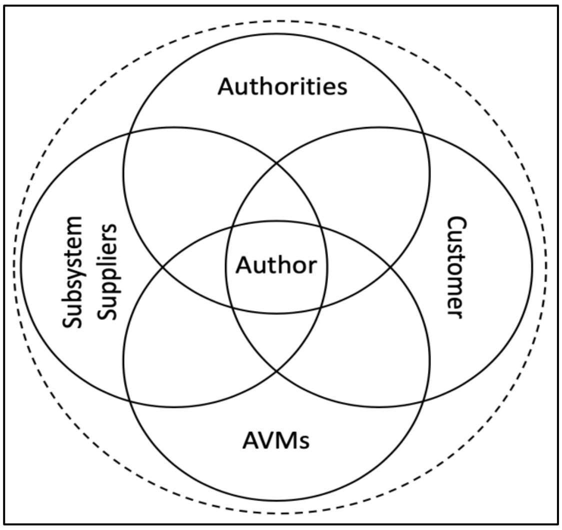

Figure 4-2. The author's central position in establishing the research question (Author).

4.2.2 Visiting and interviewing different key informants

Initially, the topics considered for this research project covered many issues related to the performance of AVMs and their ability to achieve customer satisfaction. The topics included stakeholder issues, strategy, marketing, competition, supply chain management, customer behaviour and B2B relationships. These discussion topics were raised with key informants from relevant entities using prepared questions (Appendix B) and were discussed with the owners and management of five visited AVMs located in the Gulf States. Further interviews were held with AVM representatives at the BIDEC defence exhibition in Bahrain in November 2017. The author's colleagues from AVMs and other manufacturers reviewed the interview questions (piloting) and suggested improvements. A consent letter (Appendix C) was shown to respondents before conducting the interviews.

The author subsequently visited five AVMs in the Arabian Gulf Area, four based in UAE (Mahindra, NIMR, Al-Asbar, and Streit) and one in Saudi Arabia (Al-Tadrea). These were selected from among 29 AVMs in the UAE and 3 in Saudi Arabia based on ownership type and production criteria. (1) Mahindra Armouring (Mahindra, 2019) is part of the Mahindra & Mahindra international group which deals with different markets, such as aircraft, commercial cars, electronics, agriculture, and the defence industry. The company has many AVMs on all continents, including Mahindra Armouring in the UAE. (2) NIMR (Nimr, 2019) is a semi-government enterprise controlled by many national individuals. It is one of the UAE's offset programmes (TAWAZUN), and the government owns ~60% of the company. (3) The Al-Asbar Group (Alasbar, 2013) is owned by a UAE entrepreneur who applies his innovative ideas to the company products. Al Asbar is located in Dubai, and the UAE army uses the company for some of their needs. (4) The Streit Group (Streit, 2019) is a global company, with a head office located in Ras Al-Khaimah, UAE. The group is owned by an international entrepreneur who aims to increase its market share by following a differentiation strategy and through the presence of in-stock ready vehicles. Streit products cover a wide geographic area. (5) Lastly, Al Tadrea (TMC, 2019) in Saudi Arabia is owned by an entrepreneur inspired to serve his country by introducing new ideas. Al Tadrea produces many values in addition to its AVM activity.

These visits included interviews with the owners, CEOs, management and technicians, as well as departmental tours, including of the shop floor. During the author's career, he has noted many good and bad practices within various AVMs which were the main source of information when formulating the objectives of this thesis. The author targeted AVM owners and management initially to discuss the managerial aspects. Interviews with production line and support department personnel were also held, sometimes informally. However, most of the AVM management politely refused requests to interview their subordinates in private, so all dialogue took place with managers present. Some of the interviews started with a presentation about the AVM and then the prepared interview questions were discussed. The author followed the Carat Security Group attempt to operate in Bahrain and the production of the first armoured vehicle made in Bahrain (Faisal). In addition, the author observed many of the production processes within AVMs in Belgium, Canada, and the USA. As a commissioned officer within a military (customer) organisation, the author also participated in acquisition projects, and discussed the abovementioned issues with colleagues, who also raised further crucial points that will be addressed as part of the thesis objectives.

The visits and interviews elicited many facts which inspired the author to construct the following hypotheses as an approach to tackling the research question:

1. There is a relationship between national defence strategies and both the performance of AVMs and customer satisfaction.
2. There is a significant relationship between the enterprise business strategy of AVMs and customer satisfaction.
3. There is a significant relationship between the enterprise supply chain and customer satisfaction.
4. There is a significant relationship between the conceptual design process, productivity, T&E, and customer satisfaction.
5. There is a significant relationship between customer satisfaction and interactions with the AVM, comprising involvement, trust and commitment between the AVM and customers as well as other parties such as subsystem suppliers, T&E providers and R&D institutes.
6. SE can help management to develop and optimise solutions that ensure customer satisfaction.

The NDS, business strategy, supply chain, design concept, productivity, T&E, and relationships are independent variables, whereas customer satisfaction (including autarky as part of the NDS) is the dependent variable. These are explored in the following integrative literature review.

4.2.3 Integrative literature review

Having identified the independent and dependent variables, an integrative literature review was conducted (Chapters 2-3) to cover all elements that lead directly or indirectly to the goal of customer satisfaction, including autarky as a component of the NDS. Discussing the independent variables may not lead directly to the dependent variable, so the literature analysis made it possible to include many consecutive elements that gradually or cumulatively approach the dependent variable. The author strove to collect and refine the most relevant elements that connected the independent variables to the dependent variable and to determine gaps that this thesis must fill. Thus, the purpose of the literature review was to identify the problem, explore the related literature, and present the most relevant subjects in order to ensure that the sequence of ideas would lead to powerful solutions.

The integrative literature review considered eight aspects (see Figure 3-16). The first aspect is the NDS where the Gulf States lack a published NDS, thus affecting the performance of all national defence manufacturers that decide to compete with manufacturers from developing countries with a published NDS. Moreover, the NDS can be related to the enterprise business strategy, both of which control AVM activities that influence customer satisfaction. Some examples were presented to confirm the benefit of an NDS and how it can support national manufacturers and fulfil the national goal of autarky. The second aspect is called the enterprise business strategy which plays a significant role in controlling the activities that lead to customer satisfaction. The literature review explained the importance of reviewing the external and internal environments to prepare a strategy that acquires necessary resources to cope with the environment, and elevates the resources that achieve customer satisfaction in order to deal continuously with the dynamic environment. The third aspect is the supply chain; the literature reviews defined elements that ensure a robust supply chain (network) supported by adequate regulations issued as a part of the NDS and reinforced by the enterprise business strategy. The literature review recommended building a relationship with subsystem suppliers and various other entities such as T&E third parties and R&D institutes to create powerful reliable networks. A robust supply chain can reduce the development cost and production lead time, and can enhance innovation, which contributes to customer satisfaction. The fourth aspect is the design concept, this phase converts need into product features by determining requirements and establishing the development process and T&E standards at every stage of development. The design concept requires the appropriate involvement of customers, subsystem suppliers, and production line functionalities to achieve values that capture customer satisfaction. The fifth aspect is the productivity aspect. Tools that enhance productivity were considered in the literature review. These enable management to reduce waste and lead times, both of which can significantly affect customer satisfaction. The sixth aspect is the T&E aspect, which is not given sufficient attention as a way to demonstrate the quality of both the product and the production process. T&E must be imposed by the NDS, together with strong regulations that ensure T&E is provided by third-party independent bodies. These requirements will help all parties to ensure that the performance of the product matches customer needs and thus increases customer satisfaction. The seventh aspect is the B2B relationship. The literature review discussed elements that promote customer satisfaction, such as involvement, trust and commitment. These three factors support interactions between AVMs and their customers, subsystem suppliers, and other entities. The contribution of SE is the last aspect that enhances the management disciplines to capture customer satisfaction. The literature review discussed how SE can integrate managerial and technical aspects, and how the use of SSM leads to a conceptual action that can enhance the overall process after comparing the real-life situation with the ideal model. A learning cycle is required to gradually improve the ability of AVMs to cope with dynamic environment.

The literature review helped to establish the central hypothesis by reviewing previous theoretical work related to the research question, leading to a conceptual framework model. The hypotheses need to be tested empirically to verify the correlation between the independent and dependent variables, especially in the AVM industry in the Gulf States.

4.2.4 Conceptual framework model

The assumptions derived from the literature review led to a conceptual framework model (Figure 3-17) that illustrates the relationship between independent and dependent variables (Kitchel and Ball, 2014). This thesis considers one ultimate dependent variable (customer satisfaction) which paves the way to another (autarky) as a longer-term goal. The dependent variable reflects multiple independent variables including the NDS, business strategy, supply chain and interactions or relationships. Moreover, each independent variable can also act as a dependent variable in a more specific context. For example, the business strategy is an independent variable, but it acts as a dependent variable in the context of the NDS; similarly, the supply chain is an independent variable but it can act as a dependent variable in the context of the business strategy. This relationship is shown in Figure 4-3.

Figure 4-3. The relationship between dependent and independent variables, showing all variables, their relationships, and all factors that affect this relationship. The relationships follow the flow of the literature review and the ultimate dependent variable is highlighted in black (Author).

The conceptual model uses this relationship to illustrate the extremes, namely the NDS and business strategy as the first and second independent variables, and customer satisfaction as the dependent variable, leading to autarky. These elements are the core of the conceptual model. The strategy is based on the NDS and business strategy, whereas customer satisfaction stands on the three main pillars of commitment, trust and involvement. The proposed conceptual model can therefore be resolved to a series of concentric circles representing the manufacturer level, the domestic level and the international level respectively together with a central element representing the SoS concept (see Figure 3-13). The manufacturer level represents the leading manufacturer’s functions that rely on the business strategy, which affects customer satisfaction, design, production, and T&E, which are necessary to produce the final product. These three functions, in addition to the subsystem suppliers and customers, form the supply chain. Last, the three parts at the bottom of the model represent the factors that affect the entire system: the stakeholders, especially the shareholders, the network, and finally the dynamic environment which emphasises the use of SoS as a concept for analysis.

4.2.5 Empirical method

The following empirical method based on the conceptual model was used to verify the relationship between the dependent and independent variables:

1. Two closed-question surveys (questionnaires) to validate the first five hypotheses, where the sixth was related to the research approach in order to answer the first five issues. The first questionnaire (AVM questionnaire) targets AVMs individuals in the three management layers (owner, managers and technicians). The second questionnaire (customer questionnaire) must be responded by customers and consumers of AVMs' products.
2. The AVM questionnaire aims to explore the opinions of all relevant stakeholders worldwide in order to achieve a sufficient number of responses to compare the two samples (developed *vs* developing countries). This is based on the assumption that manufacturers in developing countries are sufficiently mature (ideal) and that manufacturers in other countries (real) should imitate them.

4.2.6 Questionnaire

Research questionnaires have three main objectives (Sommerville and Dewsbury, 2007). The first objective, according to them, is to adopt a technique that helps researchers to collect information from pre-defined (randomly or non-randomly selected) samples of a population about their social settings and performances. Another objective is to encourage the participants to respond fairly to specific inquiries. The third objective is to discover the relationship between independent and dependent variables that influences the overall results.

An efficient questionnaire must encourage the informants to provide the required data voluntarily, directed by the given inquiries (Gorbach and Galea, 2007). The independent variables in the questionnaire can be estimated or based on previous investigations, including reviewing key informants (Kumar, 1989) and the conceptual model, which in turn is based on a comprehensive literature review aiming to reduce the study gap (Athirah *et al.*, 2012). Although the questionnaire outlines the inquiries to fill part of the gap, further complementary methods are need to close the gap completely. The quantitative questionnaire follows the conceptual model produced as part of the integrative literature review. Prior to conduct the research, the author acquired the ethical approval (CURES) from the university as an essential requirement. To enrich the output of the questionnaire, the following method was applied:

1. The preparation of two questionnaires, one for manufacturers (management questionnaire) and the other for individuals representing customer organisations (customer questionnaire). The objective was to understand the respondents' opinions about the situation and potential solutions.
2. The division of AVM respondents into those from developed countries (the control sample) and those from developing countries (the experimental sample). This quasi-experiment technique was based on the assumption that AVMs in developed countries perform ideally and AVMs in developing countries must imitate the former in order to compete with them in the future. The research objective, implicitly, declares the importance of elevating the performance of the AVMs in developing countries to reach the (ideal) performance of those in developed countries.
3. Both questionnaires comprised three main sections addressing strategies, product development and customer satisfaction, respectively. The two questionnaires were prepared carefully, in line with the following procedures:
    a. Both questionnaires were prepared based on the conceptual model shown in Figure 2-1. The topics covered in the AVM management and customer questionnaires are summarised below (the full questionnaires are provided in Appendix E):
        i. Common information including the country, position of the respondent, the type of organisation, the size of the organisation, and the type of ownership.
        ii. Strategic issues including the effect of both the NDS and enterprise business strategy. One of these questions asks whether the AVMs prefer strategies such as cost-leadership and differentiation (the respondents are required to rank the different strategies).

iii. Management issues concerning the preparation of resources and various capabilities, TQM tools, and hiring ex-military personnel.
iv. Design and T&E processes.
v. The involvement of customers and subsystem suppliers at different stages of the development process.
vi. Issues concerning the network and supply chain, including the use of innovative concepts, and involvement of R&D and T&E institutes.
vii. Issues concerning the enhancement of customer relationships.
viii. Rating all issues that affect customer satisfaction.

b. The respondents were asked to provide four types of answers:
i. Selection from a defined set of choices.
ii. A seven -point Likert scale to broaden the choices.
iii. Ranking the choices.
iv. Rating the choices.

4. The two questionnaires were reviewed by the thesis committee members.
5. The two questionnaires underwent piloting. The AVM questionnaire was sent to three AVM individuals well-known to the author and the customer questionnaire were sent to three individuals who had participated in the acquisition committees within their military organisations for the same purpose. The feedback was incorporated carefully into the two questionnaires.
6. A consent letter was prepared by the author (Appendix D) and reviewed by the research supervisor.
7. The two questionnaires were examined using dummy results, which were recorded using SPSS software. The interactions between the independent and dependent variables were examined. SPSS is also used to compare two independent samples (AVMs in the Gulf States *vs* AVMs in developing countries) to see if there was any significant difference between the samples regarding the factors that affect customer satisfaction.
8. The two questionnaires were then uploaded to the Qualtrics site (as recommended by the university) as a professional platform to deliver the questionnaire to the selected respondents. Qualtrics offers the following:

a. The author may send emails including the questionnaire link to the selected respondents; or

b. The author can feed Qualtrics with the respondents' emails, and Qualtrics will send an email, asking the respondents to complete the questionnaire.

9. The author used the first method to ask AVM management personnel whether or not they would like to participate, bearing in mind the sensitivity of dealing with such a community.
10. The customer questionnaire was not permitted by the military authorities for reasons of security and confidentiality.
11. The following distribution and collection process were used for the AVM questionnaire:
    a. The author contacted many AVM owners and managers around the world using (1) their personal emails, (2) telephone calls to request permission to send a questionnaire, and (3) using the generic .info email address at each enterprise. Those agreeing to participate received an email containing the following questionnaire link:

       (https://cranfielduniversity.eu.qualtrics.com/jfe/form/SV_6KcqRItxWhDt7pj)

    b. The respondents were asked to share the questionnaire link with further representatives of the AVMs who were interested in sharing their knowledge.
    c. Furthermore, the two questionnaires began with a consent letter (Appendix B). The respondents were required to consent before opening the questionnaire link and proceeding to answer the questions.
    d. Qualtrics saves the answers associated with the IP address to indicate the location of the respondents.
12. The following distribution and collection process was used for the customer questionnaire:
    a. All targeted customers were military individuals who required permission from higher authorities. The necessary communication through the appropriate military channels was carried out.
    b. The military authorities in the Gulf States found that answering most of the customer questions would break their security and confidentiality rules.
    c. However, personal conversations with several customer representatives were used in lieu of the questionnaire and the corresponding opinions were recorded.

13. To sample from among the 29 AVMs in the UAE (as well as the two in Saudi Arabia and one in Bahrain), a purposive/non-random selection method was used (AVMs in the Gulf States) because the size of the population is small. As stated above, there were two groups: the control group and the experimental group. For the customer questionnaire, military organisations in the Gulf States were asked for their responses.

4.2.7 Data collection

The author collected secondary data by conducting integrative literature reviews to prepare the enquiries, which formed the primary data. Open answers were also collected from key informants, as discussed above. In addition, the data from the questionnaires were collected online via the Qualtrics platform, which organised the data into tables as requested (as an Excel sheet or transfer to SPSS). The Qualtrics platform received 75 responses from different AVMs, and 39 (20 from developed countries and 19 from developing countries) were accepted after removing the outliers. Finally, the outliers were excluded for three different reasons: The first reason is that some respondents stopped after they read and agreed to the consent letter but they didn’t respond to the questionnaire. The second reason is that some respondents did not answer all of the questions. The final reason is that SPSS determined some outliers with out-of-range responses.

4.2.8 Data analysis

The author stood on a seven-point Likert scale with various graded response types (agreement, importance, probability, preference) resulting in frequency data. Some questions that incorporated ranking and rating techniques were used to recognise the preferences of the respondents in areas such as strategy types (differentiation/cost-leadership) that are more applicable to satisfying the customer. The questionnaire data were analysed in SPSS using two techniques: statistical analysis of frequencies and the Mann-Whitney U-test to compare the sum rank of two samples (AVMs in Gulf States *vs* those in developing countries). The statistical analysis showed no significant difference between the two samples, and no differences in terms of the consequences of the independent variables. Because both groups confirmed the relationship between the independent variables and dependent variables and there was no significant difference between them, the

Mann-Whitney U-test was used to differentiate the groups (control *vs* experimental) to illustrate which group (sample) performed better and according to which aspects.

The literature review results which represented by the conceptual models were verified by the questionnaire results, where the frequencies dimension was used. Most of the responses were four or more points on the Likert scale, which supported the confirmation of the hypothesis. The interview results and author experiences were used to confirm the explanatory questionnaire results. Finally, the overall analysis was supported using SSM to define the problems facing AVMs, the most important players, the cause of the problems, the comparison between the existing situation and the conceptual one, and finally the feasible and desirable solutions. Moreover, the literature review was used to show how developing countries can move from arms dependency to autarky/arms export by establishing an NDS with the intention of strengthening the national defence industry. Furthermore, the Gulf States situation related to their defence industry has discussed to list some of possible approaches to fulfil autarky.

4.3 The rationale behind the research methods

These methods described in Section 4.2.6 are a mixture of qualitative and quantitative, with different ontologies and epistemologies as depicted by the research “onion” shown in Figure 4-4. This thesis uses SE as an approach to deal with the challenges faced by AVMs in a dynamic environment, including SSM and the learning cycle, which are discussed extensively in the next chapter.

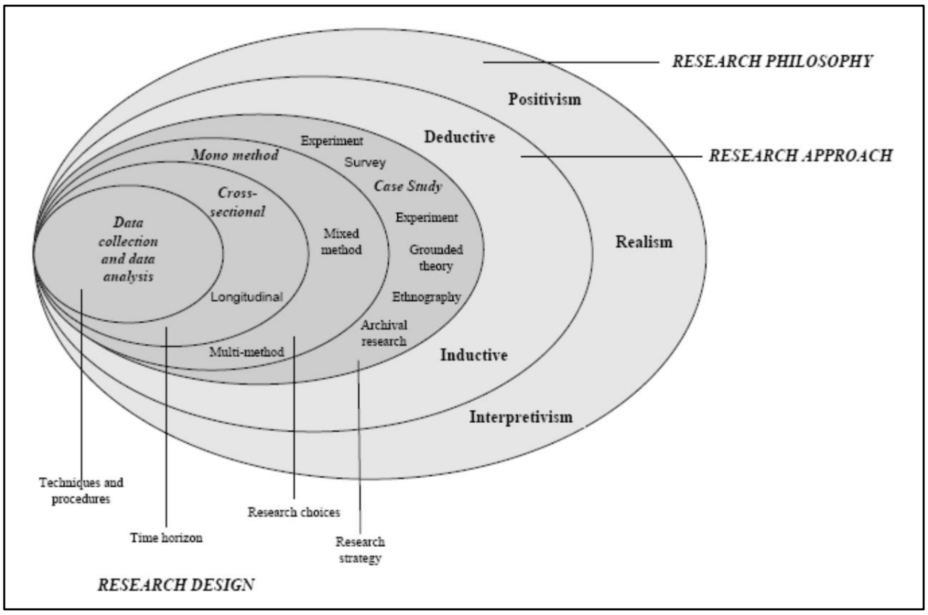

Figure 4-4. The research "onion" (Saunders, Lewis and Thornhill, 2015).

4.4 The research position

The research in this thesis aims to enable the managers of AVMs in the Gulf States to deploy their resources efficiently and thus deliver values that satisfy all of their stakeholders, military customers in particular. This involves the collection and analysis of confidential data from the providers and customers. The study also aims to develop and test a conceptual model, combining appropriate elements of related managerial disciplines verified by SoS tools, that will be used by AVMs to improve their performance. Some AVM owners are entrepreneurs who rely on their intuition to manage their resources and deal with the external environment. The customers (mainly the senior officers of military organisations) follow the fundamental aspects of the culture which is based on military rules.

The research objectives integrate many managerial and technical theories to ensure that systems can work together efficiently. The integration has three layers (Figure 4-5): the subsystems of the development system (layer 1), each enterprise's internal functions (layer 2), and the AVM (as a system) and other systems including similar AVMs (competitors), subsystem suppliers, services entities (such as R&D institutes and T&E providers) and customer organisations such as defence authorities (layer 3). The systems are continuously exposed to external environmental changes, including competition, changes in technology, political issues, and evolving customer requirements due to emergent threats. These unpredictable changes form a dynamic environment that requires flexible strategic planning and implementation. Therefore, the thesis deals with a system of many interrelated systems (SoS), and any changes in one lead to changes in the overall system. The analysis of such complexity requires appropriate data capture methods.

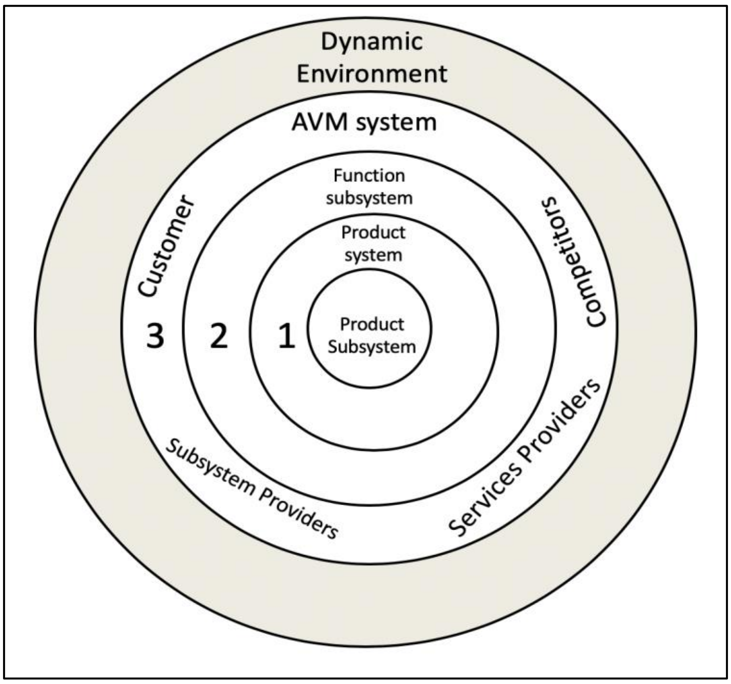

Figure 4-5. The complex system considered in this thesis (Author).

SE and SoS can be used to integrate the technical and managerial aspects of complex metasystems and can therefore be used to optimise the performance of enterprises that function within them. The research in this thesis is positioned at the overlap of three circles representing management aspects, technical aspects and SE (Figure 4-6). The diversity of opinions, which are collected from key informants at different management levels, produces large amounts of data that must be analysed using SE methods.

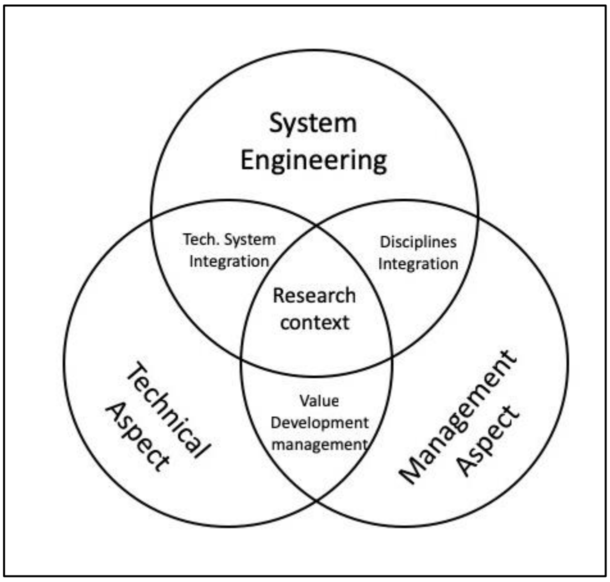

Figure 4-6. The research position (Author).

4.5 Research philosophies

This research in this thesis explores the role of AVMs in the dynamic environment of the Gulf States, and captures diverse worldviews, starting with the author's experience-based opinions, and those of his colleagues as part of the customer body, AVM owners, management and technicians, subsystem suppliers, and others. These different points of view were comprehensively explored to ensure that all factors were considered in the construction of a social context that reflects the interactions among related systems. In this sense, interpretivists (i.e., the author and other key informants) can interpret the current phenomenon to predict a new situation that can be analysed again using appropriate methods to predict a further situation, and so on (Hudson and Ozanne, 1988). The conclusion of this thesis is therefore not an end point for the research, especially when one considers the consequences of the dynamic environment and the flexibility needed to overcome unpredictable changes. Accordingly, interpretivism (constructivism) is not an end-process but one that requires continuous learning cycles. Riege (2003) argues that constructivism seeks to achieve a consensus, which is open for further interpretation in order to understand the situation correctly, enabling the researcher to break down current and future complexity. Accordingly, this thesis uses interpretivism to construct a model that confirms both the SSM and learning cycles

This study gathers knowledge derived from reviewing the literature and interacting with respondents (subjects) related to the AVM industry. This is used to construct a context (social setting). The setting is always evolving in the face of dynamic environmental changes, which forces researchers to continuously reconstruct the social setting (constructivism) by building links between the research subjects and different managerial theories and concepts on one side and the realities or practices on the other.

In addition to interpreting the current situation, the study aims to reach a solution in a complex environment by using SE tools. This requires the adoption of a paradigm multiple methods can be applied in an iterative way as part of an endless process. Pragmatism focuses on problem-solving rather than adherence to particular research mythology, and researchers are indeed urged to release themselves from exclusively adhering to a single philosophy (Creswell, 2014). Furthermore, multiple paradigms offer "*the possibility of comprehensiveness and completeness*" (Kirkwood and Campbell-Hunt, 2007). Therefore, the benefits of pragmatism and interpretivism have been used to address the complex problems described in this thesis by applying SE and SoS tools to develop solutions. The pragmatic application of SE and SoS methods is the basis of SSM (Barton, 2014) which was introduced as a means for "*learning rather than optimisation*". Moreover, such a learning process involves *"a Framework of ideas, a Methodology, and an Area of application (FMA)*", which entails a learning cycle generated by (1) constructing a framework, (2) using methods to confirm the suitability of the framework, and (3) applying the approved framework and accepting it as a part of an endless learning cycle. Barton (2014) acknowledges the contribution of pragmatist philosophers such as Peirce, who proposed involving relevant individuals (community of inquiry) available within the system dynamic. Moreover, this paradigm can be combined with the quantitative and qualitative methods as a pragmatic worldview, where "*Pragmatic arises out of actions, situations, and consequences*" as the author shifts from qualitative to quantitative research based on the research stage and situation (Barton, 2014). For example, the work in this thesis commenced with the collection of data using mainly qualitative methods, such as auto-ethnography (self-experience), observation, and interviews with key informants. Secondary data was then sourced from the literature (qualitative) to produce a hypothesis (quantitative) and a conceptual model (qualitative). Finally, the questionnaires (quantitative) were used for subsequent interpretative research (qualitative).

This study exploits the flexibility offered by pragmatism as revealed by Creswell (2014). Creswell observed some advantages of the pragmatism as a powerful research philosophy. Pragmatism does not follow any of the earlier ontologies, where a specific method, either quantitative or qualitative, must be applied. Another remarkable advantage is that researchers are free to select the most suitable method to ensure the best way to acquire the necessary knowledge for a specific stage through different research phases. Also, pragmatism allows researchers to use two methods simultaneously to enhance the understanding of a research problem and solution. Furthermore, pragmatists decide what, how and when to investigate based on the predetermined order and sequence. Finally, Creswell mentioned that pragmatists can investigate the social, historical and political context and focus on what happens externally, including other worldviews as well as their logic thinking.

Finally, this study is based on the assumption that several causes can predict one effect (customer satisfaction), which is the main research objective. These assumptions may not always hold in reality, but they have been used to build the literature review to produce a conceptual model. This reflects the philosophy of positivism, which is defined as an approach that "*provided positive and predictable knowledge*" (Cibangu and Hepworth, 2016), thus involving inductive epistemology in the literature review (Creswell, 2013). Positivism was used to prepare the list of independent variables (defence strategy, enterprise strategy, supply chain, design factor, productivity, and T&E) leading to the dependent variable: customer satisfaction.

These research issues are summarised in Figure 4-7, where the upper box lists the three selected ontologies (pragmatism, interpretivism, and positivism), the middle one explains the criteria that must be followed, and the lower one demonstrates all of the adopted methods, which are discussed below.

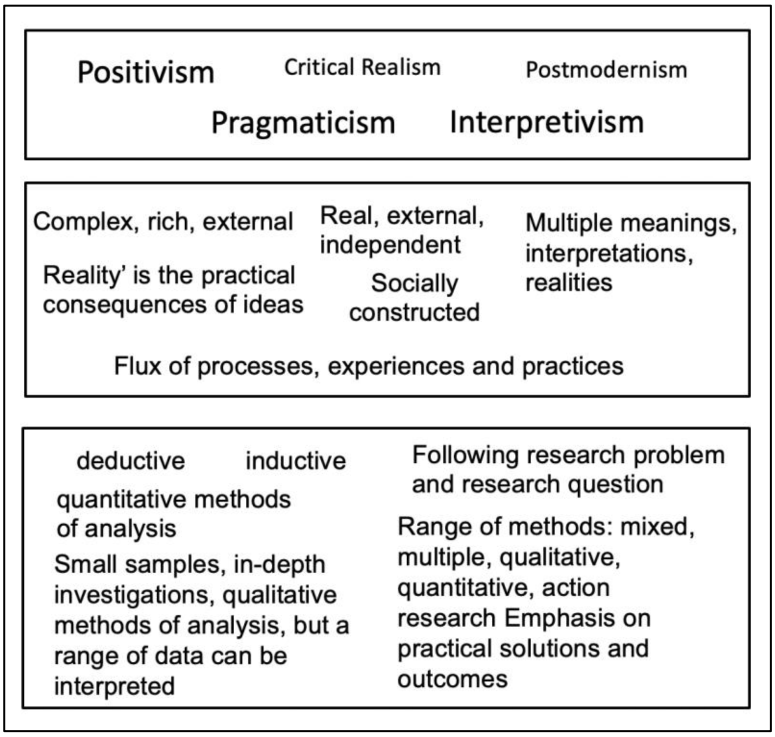

Figure 4-7. Selection of research philosophies and methods applied in this thesis (Saunders, Lewis and Thornhill, 2015).

The relationship between the author, theories, participants, and the research topic must be very strong to investigate the problem in detail and approach a solution. Jonker and Pennink (2009) describe epistemology as "*the philosophy of knowledge, especially with regard to its methods, validity, nature, sources, limits and scope*". They add that the epistemology is used to justify the collected opinions and data to reach some beliefs in relation to the selected ontological assumption. By deciding these assumptions, the epistemological assumptions are then considered mainly to establish a relationship between the researcher and other interested parties, and the outputs of appropriate research methodologies. Epistemology can be accepted as a domain of all related knowledge regardless of its origin and type (Tsoukas, 2004).

4.6 Research approach

Having understood the rationale behind the three philosophies selected for this research, it is important to determine the research approaches, which include both deductive methods, which involves testing the principles, theories and real acts from a case study, and inductive methods which lead to new conclusions (Riege, 2003).

Deductive methods connect the researcher to past theories that are relevant to the research subject. Accordingly, brainstorming with interested and experienced individuals was used to capture all aspects that enhance the performance of AVMs, support the relationship with their stakeholders, and increase customer satisfaction. These aspects were included in the (exploratory) integrative literature review to list six positivist hypotheses which are considered the pillars of the research. They were used to develop the empirical questionnaires targeting AVM personnel and customers.

Inductive methods use the results derived from different data collection methods (such as the two questionnaires, auto-ethnography, and case studies) to construct a theory through interpretivism. SE tools (pragmatism) are used in this study to validate the findings from other data. Indeed, pragmatism is the use of abduction, which enables the researcher to use both deductive and inductive approaches in an iterative manner based on the research questions (Venkatesh, Brown and Bala, 2013). Pierce, a scholar of systems thinking, considered "*abduction as being at the heart of pragmatism*" (Barton, 2014).

4.7 Research methodologies

The methodology used in this thesis is coherent with the processes and methods through which researchers acquire knowledge about the social context of the study (Creswell, 2007; Edwards & Skinners, 2009; Punch, 1998, 2013). Quantitative and qualitative research can be regarded as the extremes (Walliman, 2011), representing the difference between the nature of different sciences, i.e. natural or social sciences. The use of both in a research project depends on the degree to which one method can help in exploring or interpreting the information needed to lead to the other method. Therefore both can be used to the researcher's advantage, lessening the differences between them especially in the context of pragmatism, as shown in the following examples (Bryman & Bell, 2015): First, quantitative researchers have recently came to depend more on observations and interpretations to complement their experimental findings in the laboratory. Observations and interpretations are qualitative tools in social settings because the interaction between the researcher and various subjects must be sufficiently strong to understand the real situation. Second, qualitative research tends to answer defined objectives similar to natural or quantitative research objectives. Third, quantitative research depends on theory testing. Similarly, it relies on previous theories and concepts to derive new hypotheses for further investigation. Fourth, although realism is an essential part of quantitative research, qualitative research tends to use such an approach to investigate how the social world can reshape itself on a daily basis.

In the same context, Creswell (2014) argues there is little separation between the qualitative and quantitative approaches and suggests that the mixed method forms a strong bridge between them to solve problems which are complex and dynamic in nature, and in environments requiring a pragmatic approach. The mixed method combines both numerical quantitative and qualitative methodologies by articulating numeric values using reasonable words to understand the research issues in more detail. Moreover, Creswell (2014) defines the combination of quantitative and qualitative methods as a pragmatic worldview where "*Pragmatic arises out of actions, situations, and consequences*".

This research combined quantitative and qualitative methods based on Hegde (2015) principals. According to him, the data collection process must be consistent with the research questions and the "*nature of the setting*" that controls the progress of the "*field study*" as considered under the pragmatism paradigm. For this thesis, the research questions led to the literature review (secondary data collection), which examined the relationships between these disciplines and the ultimate research goal: enhancing customer satisfaction. The literature review was used to prepare the next data collection process and interpret its results, using a method that is consistent with Hegde (2015). Second principal is that methods and observations are situational, i.e. based on the situation of the subjects and the progress of the research. In this sense, the research methods were selected according to the data collection situation and the research stage. In some cases, both methods were used simultaneously. Third, disorganised data collection is most likely when the data are qualitative, as emphasised by the pragmatists. The author strove to collect a lot of secondary data, the majority of which is not included in the thesis, but these data have been embedded implicitly in other disciplines as a complement and for clarification. For example, marketing management was not discussed in this section but is embedded in the strategic management and customer satisfaction sections to clarify some of their elements.

The next principal of Hegde (2015) is that the use of case studies enhances the quality of the research. The situation of AVMs in the Gulf States has been discussed as a case study, leading to recommendations to achieve better performance in order to capture customer satisfaction. The case study has enriched the research with valuable data and the outcomes can be generalised to include all AVMs worldwide. The research sits between two major events (publishing an NDS and achieving autarky), with customer satisfaction positioned in between. Similarly, AVMs in the Gulf States need a published defence strategy to enhance their performance, support the national defence industry and strive for autarky. The use of a case study required the application of different methods in order to collect the necessary data. In most cases, according to Hegde (2015) is that qualitative research depends on the "*explicit interpretations of meanings and functions*" of the participants' observations and conversations, including the researcher. However, quantification in the form of statistics can be used to support the interpretations. The research in this thesis depends on both types of methodology (qualitative and qualitative). For example, the "*explicit interpretation*" has been exploited in two instances: to clarify the current situation at an early stage of the research by interviewing key informants in order to construct the literature review and conceptual model (qualitative) and to combine the SPSS outputs based on the questionnaires (quantitative) with different opinions gathered using various (qualitative) methods in an explanatory manner. Last principal is that the organisational researchers must avoid the investigation of daily practices and focus instead on the organisational norms which represent the overall policies and procedures used as guidelines for daily practice. This issue is very important for researchers, given that observing daily practices may lead to incorrect conclusions. For example, during site visits undertaken by the author, the AVM management attempted to present everything positively and the technicians were pressured to provide ideal answers. This requires a knowledgeable investigator who can recognise the daily practices from the organisation's overall norm. The experience of the researcher in the field can therefore play a significant role.

Kasecker (2008) proposed six research designs that allow the application of qualitative and qualitative methods either sequentially or concurrently: convergent, explanatory, exploratory, embedded, transformative and multiphase. An alternative scheme with four mixed-form designs has also been suggested (Venkatesh, Brown and Bala, 2013). This thesis uses the design shown in Figure 4-8, which is divided into two main parts: qualitative data collection and quantitative data collection.

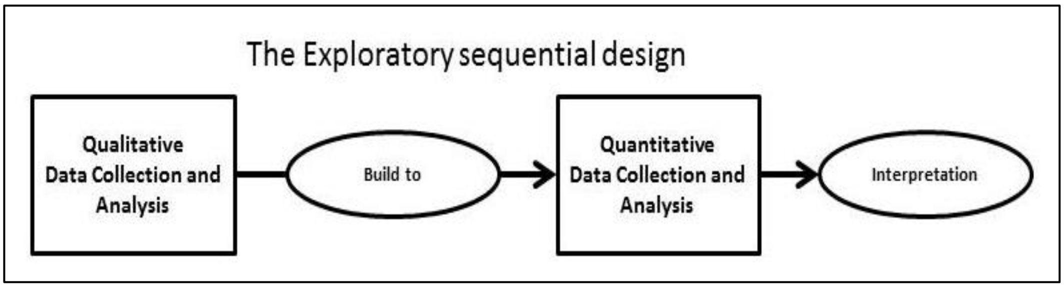

Figure 4-8. Exploratory sequential design of mixed qualitative and qualitative research methods (Kasecker, 2008).

In this thesis, the qualitative data collection and analysis are based on the assumption that AVMs require essential concepts reflecting different management disciplines, such as strategic management, supply chain management, marketing management, quality management and SE. These disciplines enable the AVM management to operate their enterprise efficiently and effectively and to achieve sustainability in the market despite the dynamic environment. The need for this approach increases when one understands that the enterprises are controlled by entrepreneurs. Therefore, the research began with an exploratory literature review of the management disciplines organised as shown in Figure 2-1, which is used to build the quantitative data collection tools (questionnaires). On the other side, this thesis uses the quantitative data collection and analysis by using two questionnaires (AVMs and customers) which were used to investigate the extent to which the management disciplines, discussed in the literature review, influence the strategic policies of AVMs (case study) and can be used to enhance performance.

In addition, the author used the case study method to explain how the business and product development challenges faced by AVMs provide an excellent case study for three reasons. First, it can reflect how SE and SoS can be used to deal with complex organisational situations. According to Gummesson (2017), "*Case study research is the traditional name of a methodology for studying the complexity of the 'real' world. It can include any issue which the researcher finds worth studying*". Second, AVMs are connected with many stakeholders, each with a different understanding of the AVM's performance. Hence, achieving satisfaction for all stakeholders is, in itself, a challenge. In this regard, Farquhar (2012) claimed that the aim in using a case study is to "*dig deep, look for explanations and gain understanding of the phenomenon through multiple data sources and through this understanding extend or test theory*". Third, the supply chain issues faced by AVMs can be examined through contemporary managerial processes discussed in the literature review. These have significant operational effectiveness on SMEs owned by entrepreneurs and operating in dynamic environments. It has been noted that the case study is useful for both theory development (inductive) and testing (confirming or conforming), ultimately resulting in the construction of a sound theory (Klenke, Wallace and Martin, 2015). For example, a conceptual framework is created by looking at case studies and combining this with personal experience and the literature review. The researcher, as a subject within the research context, then interprets the data in order to construct a theory.

The author also used the quasi-experimental method (known as non-equivalent groups) to compare the AVMs in the Gulf States (experiment group) and AVMs in developed countries (control group) because the latter employ best practices that the former should follow. This allows the non-random selection of subjects for the analysis of independent variables (Gill and Johnson, 2002) and therefore the quasi-experiment is a "*well-controlled research design*" (Coolican and Coolican, 2014)

Finally, the author relied on both pragmatism and interpretivism to explain and interpret the status of AVMs in the real situation of the Gulf States. These situations are understood by collecting different worldviews, thus revealing current deficiencies in the AVMs. Corrective actions can then be developed using SE tools to enhance the strategic, supply chain, design and T&E aspects of the conceptual model.

4.8 Interpretation (explanatory)

Qualitative methods such as observation are insufficient unless followed by interpretation, in which "*critical rationalism*" is needed (Hegde, 2015). Sofaer (2002) refers to the temptation to generate useful information from previously collected raw data as an interpretation, a key part of qualitative methodology (Hegde, 2015).

Goldkuhl (2012) considers the interpretation or explanatory method as an interpretivist paradigm and thus distinguishes it from the pragmatist ontology, the latter seeking to construct knowledge while the former is used to understand the data. Indeed, the shift from one paradigm to another is applied in this thesis, for example (1) flexibility in deciding the most appropriate method is necessary to proceed to the next stage of research; and (2) switching back and forth between deduction and induction (which is known as abduction). This powerful and pragmatic approach is described as a technique where the author is free to select any method during the course of research (Venkatesh, Brown and Bala, 2013). The transition between deduction, where the researcher assesses a theory, to induction, where the researcher strives to explain a theory, requires an understanding of the situation and accordingly the construction of a new situation at different stages of research (Feilzer, 2010). In this thesis, the interpretation of SPSS results was supported by additional complementary methods such as auto-ethnography and phenomenology. Moreover, SE tools such as SSM were used to analyse the problems and provide appropriate suggestions, as discussed below.

4.9 Systems engineering as an explanatory approach

As discussed at the beginning of this chapter, the AVMs can be considered as systems within a larger SoS which is exposed to a dynamic environment, such that the entire SoS must be modelled in a systematic manner (Barton, 2014). This approach is ideal to address the current situation of AVM industry in the Gulf States, where AVMs are more in need than similar entities in developed countries due to the lack of essential supporting factors in the wider environment. Checkland's SSM is an appropriate SE tool for the analysis of AVMs and the proposal of corrective actions based on stakeholders' worldviews. However, SSM has some limitations resulting in its replacement with the conceptual model discussed above. Even so, both models can complement each other, and can be used with the learning cycle model to gradually enhance the performance of AVMs by focusing on customer needs and the appropriate allocation of resources to foster sustainability in the dynamic environment.

4.10 Research limitations

The limitations of the research described in this thesis are summarised below:

1. The research omitted one key means of data collection: a customer questionnaire. The military authorities in the Gulf States refused to pass the

questionnaire to their staff citing confidentiality and security issues. However, the same questionnaire was filled by AVM personnel to capture their opinions.

2. The number of individuals willing to answer the AVM questionnaire was lower than expected. The researcher sent many emails to AVMs around the world, but there were relatively few responses. Most of the individuals agreed to participate due to the previous relationship between the author and the AVMs' managers and owners. Moreover, the answers provided by management during visits stressed the positive aspects and downplayed the negative ones. However, the researcher's shop-floor visits revealed some crucial points that have been discussed throughout this thesis.

4.11 Summary

This chapter describes the methodology used to answer the research questions. The methods were selected based on the current research situation, the researcher's position, the research subjects, and the appropriate way to collect and analyse the data. This thesis deals with a complex issue comprising many interrelated systems, and any changes at the level of an individual system have a knock-on effect on the wider metasystem. In order to deal with such complexity, a pragmatist philosophy was applied to encompass all the related issues and an interpretivist philosophy was applied to collect perceptions of the real situation from respondents. Pragmatism allows the researcher to choose the most appropriate method at any stage or research, including switches between qualitative and quantitative methods if necessary. The qualitative methods included an integrative literature review, auto-ethnography, phenomenology and a case study, whereas the quantitative methods featured two questionnaires and their statistical analysis. The methods used at different stages of the research described in this thesis are summarised in Figure 4-9. Last, it is important to declare that this research has relied on CURES system to meet the ethical requirement (see appendix A). Also, the necessary consents have been persuaded from all participants based on the letters browsed in (Appendix B and Appendix C).

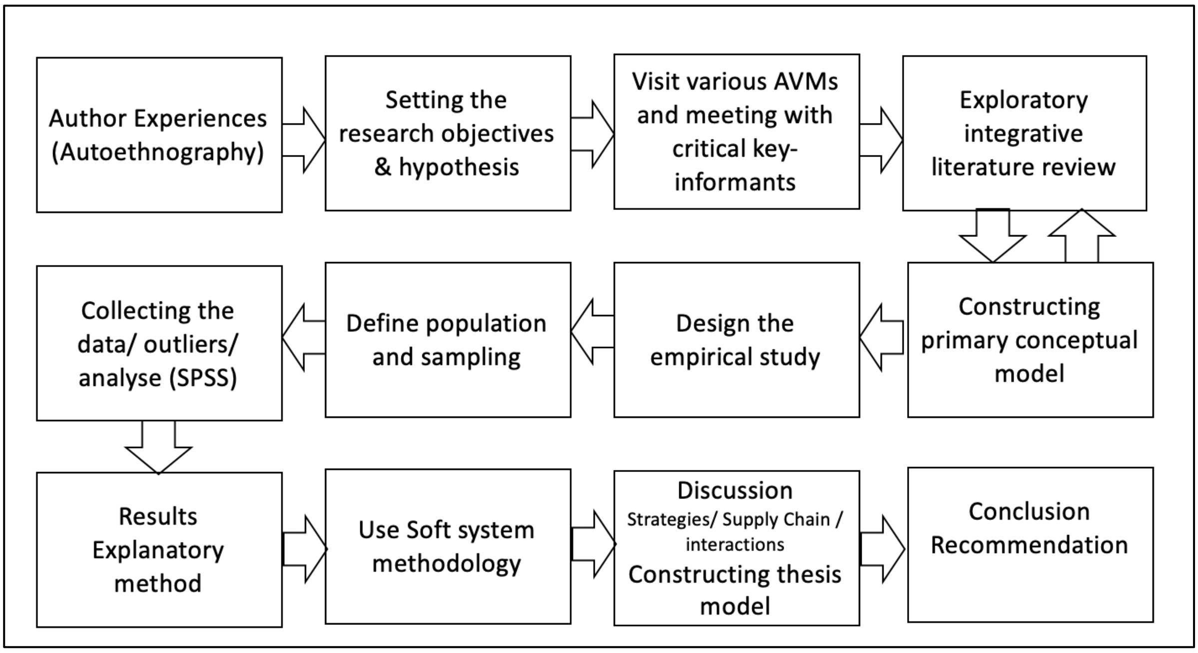

Figure 4-9. The research methods used at different stages of the research described in this thesis (Author).

5 Finding, Analysis and Discussion

5.1 Introduction

In this chapter, the data collected (findings) from the questionnaires and different sources mentioned in the last chapter is analysed aspect by aspect in the following sequence: strategy, supply chain, design, T&E and interaction. Before the analysis, some key information about the visited AVMs in the Gulf States (see Table 5-1) is presented for context. The following data have been collected by the author during his visits to the five mentioned AVMs.

Armoured Vehicle Manufacturer	Country
Streit Group	UAE
Al-Tadrea	Saudi Arabia
Al-Asbar	UAE
Mahindra Armouring	UAE
NIMR	UAE

Table 5-1. the five AVMs visited by the author (Author).

Guerman Goutorov (entrepreneur) founded the Streit Group and has striven to create a leading defence solution company. The Streit Group operates in 14 countries and serves customers all over the world. Streit is managed by qualified staff alongside with continuous presence of the owner. Streit recently has its HQ in the UAE (Ras-Alkema free zone) with a complete facilities including R&D centre and training capabilities. Al-Tadrea (formerly Al-Araba) was founded in Saudi Arabia by Fawzi Sabri, who has added his creativity to many products, with valuable support from ex-military mentors Al-Tadrea managed by the owner who hold an engineering qualifications with other qualified shop-managers with considerable amount of technical experiences. In addition, Al-Tadrea owner uses ex-military individuals to help him in discussing operational aspects. Al-Tadrea, alongside two other AVMs in Saudi Arabia, has covered the needs of the national security agencies (including the National Guard, Armed Forces, and Interior Ministry) as well as developing products for Saudi civilians. Al-Asbar was founded by Rashid Alameri and his brother in

Dubai[7]. Both have considerable amount of technical knowledge related to armoured works where Rashid's brother is a mechanical engineer. Combining their technical knowhow and creativity, they now produce an armoured vehicle used by the Emirates Armed Force, as well as producing turrets and gun mountings for other forces, and armoured vehicles for money transfer [8].

The other two AVMs, Mahindra Armouring (UAE) and NIMR (UAE), are managed by qualified individuals. The manager of NIMR is trained to doctoral level and has assembled a management team of qualified Emiratis to design and market their high-standard armoured vehicles (N35, Hafeet and Ajban), one of which is a successful product in Yemen. The NIMR board has equipped the company for success, including the provision of new air-conditioned workshops and stores. NIMR has also established a strong network of credible subsystem suppliers. Unlike the other AVMs, NIMR produces vehicles with chasses of their own design. In contrast, Mahindra Armouring is a small subsidiary of the Mahindra & Mahindra group, which works alongside its sister companies Mahindra Logistics and Mahindra Auto. This ensures they source the best accessories for an armoured vehicle, which can be designed and built into a highly integrated system. Mahindra Armouring is managed by a highly qualified CEO, while the design and manufacturing operations are managed by an ex-military officer with a technical background. Regardless of the formal structure of NIMR and Mahindra, entrepreneurship is still governing the creative thinking in both companies.

5.2 Questionnaire data analysis

The questionnaires were analysed using two methods (discussed in Chapter 4): (1) SPSS to count the frequency of respondents' opinions, which were expressed using a seven-point Likert scale and (2) Mann-Whitney U-test to compare the experimental group represented by AVMs located in the Gulf States (GCC-AVMs) and control group represented by AVMs not located in the Gulf States (NGCC-AVMs) such as the UK, the USA, Turkey, Kenya, Switzerland, France, Germany, and Malaysia according to the quasi-experimental methods.

[7] Collected from the author's visits to the mentioned AVMs.

[8] Collected from the author's visits to the mentioned AVMs.

5.2.1 General data

The respondents are assigned to five management levels to acquire opinions from these levels thus improving the internal validity of the research by triangulation. Opinions were gathered from CEOs, senior executives, managers, technicians, and supporters, representing 8%, 26%, 53%, 8%, and 5% percent of all respondents, respectively. Approximately half of the AVMs were SMEs and the rest were large enterprises (LES).

5.2.2 Strategic Aspect

5.2.2.1 Frequency analysis (strategic aspects)

The questionnaire responses relating to strategy (6-17) are summarised here based on the frequency of the Likert scale responses. It is so important to mention that most of the responses lay to the right side of the Likert scale (5–7), which means that most respondents agreed with the thesis hypothesis concerning strategic aspects. The response to Question 6 reflects the fact that most of the respondents were completely unaware of whether a defence strategy was available in their countries. For example, 15 of 20 GCC-AVM respondents answered ‘Yes’, whereas all Gulf States lack a published strategy. These incorrect responses may reflect the fact that most of the respondents represent low-level management, and are more concerned about the enterprise’s strategy than a NDS. The high-level management were certainly aware of the lack of an NDS where the answers obtained from them are noticeably (No). However, understanding the NDS would empower low-level management (technicians), especially employees with responsibilities for developing products which contribute towards fulfilling the NDS. The questionnaire (Question 8A) shows that all of the respondents agree on the importance of having as NDS. Similarly, the existence of an NDS in adjacent countries or other international (developed) countries is essential (Question 8B). The survey also reflects the importance of the enterprise’s business strategy in enhancing its performance. Moreover, the respondents (Question 13) preferred to examine the enterprise’s business strategy on a regular (annual) basis and during critical environmental changes, allowing the rapid reallocation of resources according to current conditions. With regard local enterprise capability, most of the AVM respondents believe that the appropriate selection of a business strategy enables enterprises to compete locally, regionally and internationally.

Selecting the appropriate strategy is essential to the success of enterprises, therefore, most of the AVM respondents prefer to adopt differentiation strategies (Table 5-2). Differentiation is ranked top (21), followed by focus-differentiation (12). In the second rank, cost leadership is preferred (13), and in the third rank the preference is focus-cost (19).

Rank	Cost-Leadership	Differentiation	Focus-Cost	Focus-differentiation
1	7	21	0	12
2	13	11	5	11
3	10	4	19	6
4	10	4	16	11

Table 5-2. Ranking of different strategies (the highest score in each rank is shaded) (Author).

5.2.2.2 Mann-Whitney analysis (strategic aspects)

The Mann-Whitney U-test compares two nonparametric independent samples to examine whether they belong to the same population. The two samples showed no statistically significant differences, reflecting the fact that they represent the same population (AVMs). This similarity probably reflects the fact that most AVMs in the Gulf States are not native (they originated in developed countries) and both categories share similar goals and perceptions in terms of their future vision. However, the Mann-Witney U-test can distinguish between the two groups in terms of the mean ranks or the sum of the ranks. The higher the mean rank in the Mann-Witney test means it is better than the other with lower mean rank, the difference between the two mean ranks is not important (see Appendix G). The following data analysis based on which has a higher mean rank regardless the difference between them.

It can be recognised that NGCC-AVM personnel have a stronger belief in their NDS in terms of defining their customers' future needs. This is because NGCC-AVMs have recognised the advantages of having a published defence strategy as in the case of the developed countries, such as the US and UK. In addition, the GCC-AVMs have shown more interest in other countries' defence strategies (regionally and internationally). It was observed and acknowledged by the key informants that

GCC-AVMs depend mainly on subsystem suppliers from developing countries, whose strategies are of high concern to the management of GCC-AVMs. This is to ensure the smooth flow of subsystems and the sourcing of state-of-the-art products from trusted suppliers. Moreover, having a published defence strategy in GCC states allows NGCC-AVMs to cooperate with the GCC-AVMs with greater trust.

The GCC-AVM personnel more than NGCC-AVM personnel prefer that the NDS obliges their local customers to purchase their requirements from domestic AVMs as a priority, because local AVMs depend mainly on local customers. However, interviews with GCC-AVM management revealed some untrusting behaviour by local customers. For example, customers usually express verbally (informally) their willingness to buy their needs from local providers, but often decide to use external sources, even if the local AVM is preparing to receive the order. With regard the reliable network, the NGCC-AVM respondents placed more emphasis on their enterprise sharing a reliable network because they had already experienced the advantages of the network in enhancing their performance. Furthermore, GCC-AVM respondents were more concerned about changes in countries' relationships such as USA, the UK, Germany (main suppliers of subsystem parts) due to political issues, given that the Gulf States are more vulnerable to such instances. Indeed, these issues might considerably affect the flow of subsystem parts from the developing countries that are necessary to complement the product, with severe consequences for the development process. In contrast, NGCC-AVMs can acquire their subsystems from local providers, where political issues are not critical.

GCC-AVM respondents are keener than NGCC-AVMs to create an AVM business strategy that synchronises with the NDS, if one exists. This was important because GCC-AVMs depend more on local customers' defence strategies to estimate local customers' demands that must be embedded in the enterprise business strategy. Another reason is that GCC-AVMs are more recent than NGCC-AVMs in the industry. In fact, the GCC-AVMs require clear future NDS from their local military customers that determines the future military needs and the facilities provided to support the national industry. Finally, GCC-AVM respondents believe that their enterprises are only capable of competing within the local market due to the relatively high demand in the Gulf Area, whereas NGCC-AVM respondents believe they can compete against AVMs worldwide. However, it has been recorded that

GCC-AVMs products have reached to customers outside the Gulf area. For example, some African countries have purchased armoured vehicles from several manufacturers located in the UAE.

5.2.3 Supply chain aspect

5.2.3.1 Frequency analysis (supply chain)

From the SPSS frequencies, it has been noticed that almost 58% of the AVM respondents prefer the differentiation strategy. As a result, most of the respondents stressed the need for the AVM business strategy to ensure the appropriate preparation of resources to achieve good results through the differentiation strategy. Most of the respondents and key informants confirmed that skilled teams of technicians are required as a priority to ensure the success of AVMs to practice the selected strategy efficiently. Moreover, the responses were positive in terms of updating the production equipment, but as observed from the interviews and the visits, assembly depends more on the level of the technicians than the machines. For example, welding two armoured plates together requires high-tech welders to avoid failing overall specifications (hard steel).

The questionnaire emphasised the importance of the entrepreneurship style (compared to conventional management) in guiding the enterprise, to ensure business success in a dynamic environment by adopting innovation and, at the same time, managing the risks. Accordingly, AVMs are in greater need of such practices, as confirmed by all of the AVM personnel in the interviews. For example, Al-Tadrea in Saudi Arabia is adopting the entrepreneurship style of management because the owner likes innovation and accepts risks. Other AVMs in the Gulf Area such as Al-Asbar adopt the same style (entrepreneurship). These initiatives have allowed Al-Tadreea to establish its place in the market.

It was clear from the answers and interviews that it is essential to manage the supply of subsystems carefully in many dimensions. Certain AVMs, such as Mahindra Armour and Striet, show evidence of this practice. For example, Mahindra Armour can obtain its subsystem requirements from within the Mahindra & Mahindra business group, whereas Striet enjoys positive relationships with the suppliers of suspension and brake systems and deals with many subsystem suppliers all over the world, reducing the risk posed by political issues. Moreover, Al-Tadreea and

Striet both have an armoured glass franchise to prepare glass within their premises. Moreover, most of the respondents and key informants respected the just in time (JIT) approach as an essential practice to ensure parts could be obtained at lower cost. It was generally agreed by the AVM personnel that the involvement of subsystem providers is very important in different phases of the development process. In addition, many customers, including the author, have found that the hiring of ex-military personnel helps to establish a closer relationship with the AVMs. However, the AVM respondents were neutral regarding the hiring of ex-military individuals to work for them.

The literature review highlighted the importance of quality tools, such as ISO, TQM, six-sigma, lean management and lean-six sigma practices to enhance productivity. However, the responses were unexpected as the answers were distributed widely and levels 3–7 on the Likert scale were equally represented. These broad responses have several potential explanations such as these tools are available but not implemented properly, individuals, especially technicians, may be unaware of these tools, enterprises use these terms for commercial purposes but in reality, are not fully familiar with the principles or the results of applying these tools do not appear in the short-term.

The author did not recognise any initiatives between the R&D centres, including national universities, and industry. The author thinks, as do many of the key informants, that the R&D centres in the Gulf States do not interact with military entities because the latter are unwilling to share information. Finally, there are many factors that contribute positively to the supply chain. The questionnaire asked the AVM respondents to rank the following (Question 19):

1. The enterprise depends on management to deal with unexpected situations.
2. The enterprise depends on skilled technicians with adequate authority and knowledge to act quickly.
3. The enterprise depends on an outsourcing strategy for parts of its production.
4. The enterprise depends on relocating technicians along the production line because they are versatile.

Error! Reference source not found. shows that management's contribution (entrepreneurs) was ranked top, followed by technical skill, then resource relocation, and finally outsourcing. These observations confirm the importance of management in controlling the entire development process, followed by the technicians, so the human factor is essential to create a robust supply chain.

Rank	Management contribution	Technician Contribution	Outsourcing Contribution	Resources Relocation
1	16	13	4	6
2	9	16	5	8
3	7	8	10	11
4	7	1	18	13

Table 5 – 3 Ranking contribution of different factors that enhance the supply chain (the highest score in each rank is shaded) (Author)

5.2.3.2 Mann-Whitney analysis (supply chain)

Mann-Whitney U-test (Appendix G) reveals some essential points that must be considered. First, although entrepreneurship practices are preferred in both groups, the management skill is more crucial in GCC-AVMs, which require more preparation and control because they are newer than NGCC-AVMs. Second, TQM tools, such as ISO, six-sigma and lean management, are in greater demand in the GCC-AVMs. These AVMs need such tools to elevate their performance to reach international standards in order to compete internationally. Third, customer interaction in GCC-AVMs is more recognised because cultural factors in the GCC facilitate social interactions (as discussed in section 3.2.4). Fourth, being in a network is recognised more by NGCC-AVMs because they have positive experiences of this aspect. The broad networks in developing countries include international entities, helping each enterprise to enhance its performance. However, GCC-AVMs apply narrower networking practices, which limit their supply chain capability compared to NGCC-AVMs. Last, the location of AVMs is more critical for GCC-AVMs than NGCC-AVMs because of the facilities available in the UAE's free zones to promote the defence industry. Moreover, the high demand in the region has increased the importance of operating in the GCC area. Finally, military agencies prefer to deal with local AVMs, especially with regard to immediate orders, which more often happens in the GCC due to the lack of a defence strategy.

5.2.4 Design aspect

All five AVMs discussed above are SMEs with a very simple structure and limited human resources, especially in the design team. These AVMs design and produce three types of protective means: adding armour to civilian vehicles without altering its basic shape, adding a new armoured vehicle body to the framework of a known commercial vehicle, and the creation of new vehicles from first principles.

The type of design determines the contribution required from the design team. The addition of armour to civilian vehicles is straightforward because most of the design effort is devoted to achieving protection without exceeding the payload or gross weight of the base model. The designer must also select upgraded accessories and their new specifications, such as suspension and brake systems. The customisation of vehicles by adding new armour to the framework needs more significant design effort. After selecting the chassis, the designer works alongside the customer and other stakeholders (including marketing and finance personnel as well as suppliers) to determine the configuration, features, and functions required for the vehicle.

AVMs in the Gulf area, as emphasised in the initial review, are particularly interested in the development of bespoke vehicles, and the maximum effort is required from all departments in order to leverage the core competencies that lead to competitive advantages. All five AVMs visited by the author can produce modified base models or augmented frameworks, but only NIMR can produce complete bespoke vehicle designs featuring an original chassis, with only the power train produced by established car manufacturers. The next three sections consider these three vehicle types in detail.

5.2.4.1 Add-on armoured vehicle

Most of the AMVs visited by the author launched their businesses by adding protective armour to civilian vehicles. The design specification is to cover the passenger and engine compartments with armour plates, select the best available accessories to compensate for the higher overall vehicle weight, and introduce other features that enhance passenger safety. Suppliers of armoured steel and safety equipment work hard to innovate and introduce modern technologies to AMVs, which in turn limits the task of the designer to selecting the systems needed for integration. However, the integration of systems produced by different manufacturers can be challenging. As well as selecting the best systems, the designer must be aware of financial constraints, special customer requirements, and must retain the original shape of the vehicle. Moreover, the designer must come up with a design that reduces waste and is easy to assemble. AMVs are faced with many variables, leading to the development of alternatives with minor differentiations that are available for designers and managers to select. Traditional design methods, including design software, are insufficient for add-on armour, and designers must use additional approaches to validate their selections.

5.2.4.2 Installing armour on a chassis

Some innovative AMVs have extended their production line to develop new brands of armoured vehicles by using the chassis and the powertrain of known commercial vehicles. In this type of product, the AVMs replace the vehicle's entire body with one or two armoured compartments that are used for different purposes according to customer requirements. The armour protection is extended to include the engine, battery holders, coolant system, and fuel tanks. To overcome the additional weight and still enable the vehicle to perform efficiently, the design team replaces or enhances the suspension, brake system, and power system using appropriate parts. Finally, the design team adjusts the framework to settle the armoured compartment. After accepting the vehicle, customers state their needs in terms of equipping the vehicle with extra features and weapons, and in terms of the passenger or operator requirements to ensure operability and ease of maintenance.

5.2.4.3 Manufacturing an entire bespoke vehicle

Some AVMs design entire vehicles except for the powertrain. For example, NIMR builds armoured vehicles with an original chassis (manufactured externally) supported by a powerful Cummins engine and transmission (with an enhanced coolant system) to allow for operations in harsh environments. NIMR designs the suspension and brake systems and sources them from credible suppliers. This helps the designer during the very early stages of development because the design can accommodate the volume and gross weight of the vehicle to improve its capability and functionality. However, this method has many more variables than the add-on armour or armoured chassis designs (see above). The design process therefore needs more effort and the prototype must be subjected to extensive T&E.

The current design departments in the five AVMs visited by the author are simple, and the personnel deal with many aspects of the design process in a simple way: The design team comprises one or more designers working with high-specification software such as SolidWorks or CAD. The designer receives information exclusively from the management, which attempts to assimilate customer needs from personal meetings, from other competitors' products, and from self-contemplation. During the visits the author has recognised some critical issues that affect the final product features and thus customer satisfaction. First, the author noted that the design is often influenced by pre-made configurations for a necessary system such as the engine, transmission box, or chassis. This gives the designer limited opportunities for innovation. Second, the design team verifies the final design visually without advanced tools, such as statistical methods, to calculate aspects such as reliability, availability, and maintainability. Moreover, the design team rarely refers to any marketing surveys, which would indicate real customer needs. Third, it has observed that customer interactions are inadequate during the design phase, although the customer may provide requests before the design process begins, and might see the final drawing for approval. The design team employs one or at most two designers which negates the value of any management system. The author also perceived that designers do not prioritise customer needs correctly, and act intuitively most of the time. In fact, most customers are not aware of all of their needs, especially latent ones. In this regard, management should meet with customers to determine such needs, but some vital ones may nevertheless be overlooked.

AVMs, like other manufacturers, refer to international quality systems such as ISO9000 to provide evidence of product quality. However, the ISO system assesses the production process in terms of the manufacturer's own standards, thus it provides a relative rather than absolute quality measure. If the manufacturer is willing, tools such as six sigma and lean management must be applied internally to enhance operational efficiency and ultimately the output. In the same way, customers should be made to understand the benefits of such quality systems through their involvement in the process. Last, the AVM workers in UAE and Saudi Arabia are fitters rather than technicians. This limits their ability to discover defects during the production process or to contribute during the design phase.

5.2.4.4 Frequency analysis (design aspect)

The SPSS frequencies reveal some points related to the design aspects and will be demonstrated as follow based on its order in the AVM questionnaire. Most of the

AVM respondents confirmed the relationship between the business strategy and the design concept process. Moreover, the respondents recognised the relationship between the defence strategy and both the enterprise business strategy the design concept process. The questionnaire confirmed the importance of reviewing the defence strategies of other countries which incubate subsystem providers. The respondents have the same motivation to be part of a conventional industrial network which entails the required cooperation, integration, and collaboration. Moreover, the local network would be more beneficial because it has more advantages in terms of costs and time. AVM management were keen for local R&D institutes to share their innovative ideas for the production of unique values, but such consortia are currently unavailable.

The AVM respondents insist on having a reliable design team. However, the author noted that most of the design sections consist of two or three draftsmen (not technical designers), hence the integration among the different subsystem parts may not be considered in sufficient detail. AVM personnel in the Gulf States are low-skilled technicians (fitters), which limits their potential to share their thoughts with the design teams and develop innovative ideas for the product and production process. The AVM respondents appeared reluctant to hire ex-military individuals (their responses concentrated in the middle of the Likert scale). In the author’s opinion, the presence of ex-military individuals on the design team leads to a better understanding of the customer’s needs and the addition of valuable information concerning the operational nature of the product’s features. The AVM respondents prefer to engage in sufficient customer interaction, which adds considerable value to the developed product. Moreover, the author notes that the design team rarely refers to customer input that helped them to determine real customer needs (either for customer security reasons or the limited capabilities of the design team members). The most widely-used approach was to listen to the owner, management or marketing team to decide on system features. In addition, AVM design teams in the Gulf States prioritised the customers’ needs (requirements) intuitively without using the proper contemporary tools that are appropriate for this purpose. This suggests that customer input, especially during the design phase, is currently insufficient for designing a product that covers all needs. The involvement of subsystem providers was confirmed by the AVM respondents via the questionnaire and in interviews, but such involvement is currently negligible.

The AVM respondents agreed that quality tools are essential for the design process. Moreover, all AVMs visited by the author displayed accreditation certificates (such as ISO 9001) at their main entrance as proof of product quality. However, none of necessary tools (quality tools) were used in the design process by the GCC-AVMs. The design team verifies the final design visually without using advanced tools to calculate system reliability, availability or maintainability.

5.2.4.5 Mann-Witney analysis (design aspect)

As above, the Mann-Witney U-test found no statistically significant difference between the GCC-AVMs and NGCC-AVMs, confirming that both groups belong to the same population. However, comparing the *mean ranks* and the *sum of ranks* produced some noticeable differences between the two groups in some aspects. Frist, NGCC-AVM personnel have a stronger (higher in Mann-Whitney mean rank) belief in building a comprehensive design team that include all functions, probably due to their earlier presence in the industry. Second, High-level technicians are needed more by the GCC-AVMs because they are newer to the industry, and the presence of such technicians on the shop floor will improve the enterprise's performance. Moreover, the selection of credible subsystem suppliers is more important for the GCC-AVMs due to the risk associated with subsystems providers from other countries where unexpected political issues may arise. Furthermore, GCC-AVMs prefer customers sharing their technical knowledge with the design team because the GCC-AVMs need more information about their customers' needs and they serve local customers, who are very close to them, which makes customer involvement easier. Last, being in a supply chain network was more acceptable to the GCC-AVM respondents because the network enhances their performance.

5.2.5 Test & Evaluation (T&E) aspect

5.2.5.1 Frequency analysis (T&E aspect)

The SPSS frequencies related to T&E questions have shown some crucial issues. The questionnaire confirmed that AVM personnel are aware of the importance of T&E to the defence authorities. The AVM respondents appreciate being a member of a reliable network that includes a T&E entity, but such a network is physically unavailable and there are currently no governmental regulations to support one. It is clear that AVMs in the Gulf States depend on credible subsystem suppliers and are constantly seeking the best subsystem from well-known providers for each project. Some AVMs in the Gulf States enjoy a long-term relationship with reputable suppliers as the sole providers of certain subsystems, such as brake systems, suspension systems and armoured glass. These credible providers have the ability to test their parts before submitting them to AVMs in the Gulf States.

The AVM personnel reacted positively to hearing from customers and gathering their knowledge, especially knowledge relevant to operational dimensions. This knowledge can be used to plan for reliable T&E as the real users participate in determining the actual use of the equipment. However, the AVM personnel did not agree that customers should test their product alone because the general view was that most customers are incapable of performing the tests correctly. The author found evidence among the answers to the Likert-scale questions that some AVM personnel are unaware of the importance of intermediate tests. It has been recognised that Gulf State AVMs tend to concentrate on the final test and evaluation. The questionnaire revealed a divergence of opinion when answering the question "Do you prefer ex-military individuals within your enterprises?" This reflects the selection of respondents from all management levels, where the top level responded positively to this question but the lower level did not. The ex-military individuals can contribute in planning a reliable T&E especially in the operational side. Last, the existence of third-party T&E entities and the contribution of R&D institutes to T&E have not been recognised in the GCC area. However, the UAE military authorities host an annual event, usually in August when the weather is hottest, for all AVMs who wish to test their products for UAE military needs in the desert. According to GCC-AVM management, participation in such events provides an exceptional opportunity to test their recently-developed vehicles in a harsh environment, to certify the product from a governmental agency, and to demonstrate the vehicle's capabilities to customers. For the UAE Armed Forces, this is an excellent opportunity to browse all available values at a single event and to select the most suitable products.

5.2.5.2 Mann-Whitney analysis (T&E aspect)

As above, there were no statistically significant differences between the GCC-AVMs and NGCC-AVMs, but the following points were recognised and expanded by referring to personal experience and information from interviews with key informants. The questionnaire showed that NGCC-AVMs are more aware of the benefits of in-house and intermediate tests with their customers. The NGCC-AVMs are used to dealing with customers from developed countries, who are normally guided by a clear defence strategy which controls the T&E activities and dictates the customers' involvement. These joint activities benefit both sides. On the other hand, if involvement is optional (as is the case for GCC-AVMs) then the management think that involving the customers in production processes for T&E purposes might delay product deployment.

Customer interaction is more clearly perceived by GCC-AVMs due to the geographical proximity, cultural aspects and national similarity that they share with their customers, assuming that most of their customers are local. Therefore, the GCC-AVMs may exploit this situation to plan for better involvement to enhance the T&E process and output. Moreover, ISO certification is respected more in the GCC-AVMs and may replace T&E in some cases. Customers at times overvalue the ISO objectives and assume product quality is included, and some manufacturers exploit this to convince their customers about product quality. As mentioned above, the ISO certificate is important but can never replace T&E. Last, NGCC-AVMs have benefited more from belonging to reliable networks which constitute independent T&E entities. In addition, the presence of reliable subsystem providers within the NGCC-AVMs ensures that they receive the subsystem parts once the necessary T&E has been completed.

5.3 Application of Soft Systems Methodology (SSM)

5.3.1 Introduction

In this section, the situation of AVMs in the Gulf States is illustrated and analysed using the Soft System Methodology (SSM) as one of beneficial SE tools that offers a unique approach to highlight potential solutions to challenges facing AVMs in the dynamic Gulf States environment.

5.3.2 The seven stages of SSM

SSM compares real-world activities to systems thinking activities in seven consecutive stages that skip between the real world in stages 1, 2, 5, 6 and 7, and systems thinking in stages 3 and 4 (Mehregan, Hosseinzadeh and Kazemi, 2012). The concept is summarised in **Error! Reference source not found.** (Burge, 2015). urge (2015) adds that the seven stages conclude with a learning cycle, because the action (stage 7) can generate new a problematic situation that requires further SSM analysis. Table 5-3 provides a good example of the contribution of SE, through SSM, to help AVM enterprises create their best strategy. Military authorities and local manufacturers can also use this method to overcome some of the problems associated with the defence industry, the AV industry in particular. Moreover, AVM management can use SSM to investigate deficiencies in their overall technical and managerial performance and recommend solutions.

Stage	Analysis Type	Description
1	Real world	What to think about: Describe the problem
2	Real world	Rich picture
3	Systems thinking	Formulating the root definitions (CATWOE)
4	Systems thinking	Developing conceptual model (human activities system)
5	Real world	Compare conceptual model with the real-word
6	Real world	Defines changes that are both desirable and feasible
7	Real world	Take-action to improve the situation

Table 5-3. The seven stages of Checkland's SSM (Burge, 2015).

The following sections will discuss the case of GCC-AVMs by applying the seven stages of SSM based on information gathered from interviews with AVM key informants, customers, and some defence authority representatives, as well as the results from the questionnaire. The experience of the author was used to fill in some of the SSM requirements. Most stages will cover all aspects, whereas stage 5 (compare the conceptual model with the real-world situation) will be discussed separately for individual aspects: strategy and supply chain (design and T&E).

5.3.2.1 Stage One: Describe the problem

The current problem facing the AVM sector in the Gulf States can be summarised as shown in Figure 5-1 and is described in more detail below.

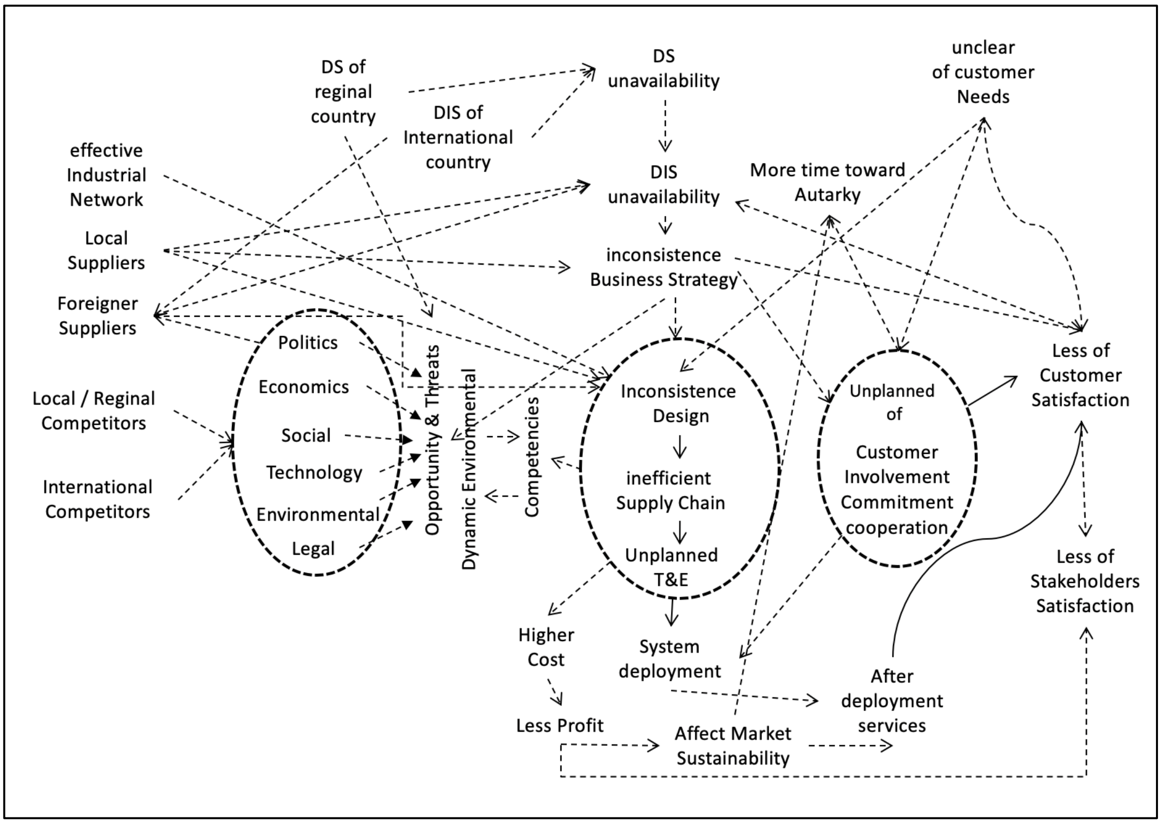

Figure 5-1. Problem-oriented context diagram of the problem situation (Author).

AVMs in developing countries like the Gulf States (GCC-AVMs) face numerous obstacles that hinder the fulfilment of their goals. Most AVMs are SMEs owned by entrepreneurs who do not pay sufficient attention to strategic preparation and accept risks despite their dynamic environment, but they appreciate innovation. AVMs deliver sensitive products to protect soldiers and VIPs from multiple threats, and these products are associated with values that fulfil their stakeholders' needs, particularly those of military customers. These military customers seek to satisfy their needs at affordable prices and deal with their providers with professional acquisition teams. However, AVMs often lack a business strategy, even though a strategy is essential for the preparation and execution of production, and the acquisition of necessary resources (core competencies) to deal with the dynamic environment. With such a strategy, AVMs can gain a competitive advantage that will enable them to compete locally, regionally and internationally. But these practices do not seem to be followed efficiently.

On the other side of the problem, the extent of customer involvement is not sufficient to communicate real customer needs before initiating the development process, leading to a higher risk of late alterations that affect the development costs and lead time, thus reducing customer satisfaction. Finally, the practices of the AVMs might be more effective if the national military authority decided to publish a defence strategy that controls the relationship between military customers and the defence industry. The lack of such a strategy affects the sustainability of the AVM market due to the absence of an industrial network, which helps each constituent's entity to reduce their associated risks and costs.

The supply chain of AVMs in the Gulf States also faces numerous risks that affect enterprise performance. These risks can be related to certain conditions, such as demand, supply, competition, network stability, production, and management style. First, the demands of Gulf State AVMs can be ambiguous, due to the lack of a published defence strategy, the requirements can be poorly defined before production commences, leading to late reworks and alterations, and immediate request for products with an urgent deployment schedule can interrupt current production processes. Second, the supply of subsystems depends on the political relationship between the Gulf State's government and the providers' country. Third, the risk is intensive when GCC-AVMs compete with reputed manufacturers with an established market share. Fourth, the network risk is related to the lack of strong local entities that can help AVMs to achieve their value. Fifth, the production risk is related to deficiencies in technical aspects that are not yet available in developing countries. In addition, most of the technicians working for GCC-AVMs possess a low level of technical knowledge (fitters) and their turnover is high. Finally, there is a risk related to the entrepreneurial style of management. Although this management style promotes innovation, the associated risks can harm the business because AVMs are SMEs. Table 5-4 summarises the risks and corresponding remedies, and Figure 5-2 illustrates the consequences of supply chain problems.

Subject	Risk	The current treatment of risk
Demands	• Demand fluctuation (ambiguous) • Needs are not defined specifically • Immediate order.	• Arbitrary prediction of future needs. • Wait for orders • Adopt an on-the-shelf strategy • Attempt to contact customers • In the case of immediate orders, AVMs allocate all of their resources to performing the task • Keep resources idle sometimes as a standby for an immediate order • Designer revises the product's technical drawing with the customer
Supply	• Supply discontinues due to political issues • Changes in the prices for supplying items • Supply items: integration problem • Supply items: discontinuation	• Assign alternative suppliers from different countries • Seek new suppliers for each project • Continuously scan the market • Use experience to test the system integration
Production process	• Small workshop has no clear separation between functions • Production process is poorly-designed/technicians do not share their views when designing the production process • Low-skilled technicians, high-turnover, no learning curve • Many projects at a time • No TQM or not applied on the shop-floor • No real cost calculation • Customer involvement is not planned • No clear plan for resource acquisition or development • No intermediate T&E	• Hire two or three designers in the design department • Hire technicians with low skills as a fitter where the shop manager monitors/controls everything • Allocate resources based on projects in progress • Customers visit the shop-floor any time they wish/there might be sudden alterations
Competition	• AVMs compete against international manufacturers • No national strategy to depend on local AVMs only • Lack of economies of scale	• Try to reduce the burden costs to offer prices below those of the competitors • Try to understand the customers' needs and offer exactly what they need
Network	• No strategy for establishing local networks • Local available entities construct a network that is insufficient with regard to type and technology • Partnerships are not applied • No R&D centres	• Mutual agreements • R&D is limited to the design phase only
Management style	• Entrepreneurs who adopt innovation and accept risks • No clear business strategy	• Continue with intuitive management projects and resources

Table 5-4. Risks associated with the supply chain and the actions taken to mitigate them (Author).

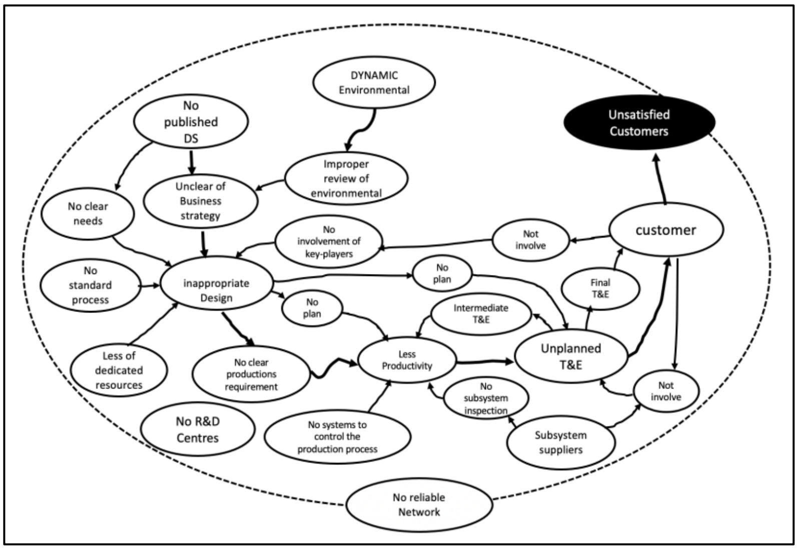

Figure 5-2. Stage one: a description of the supply chain problems facing GCC-AVMs (Author).

The design phase in AVMs in the Gulf States faces significant problem that may hinder the development process. These problems can be can be summarised in six points. First, the absence of a NDS that describe customer needs. Second, insufficient coordination with subsystem providers that led to inadequate integrations between different subsystem parts. Third, insufficient involvement of technicians of different functionalities who can add significant values to the product features and development process. Fourth, design process does not include the design of the production process and the T&E operations. Sixth, inappropriate interference by the owner who, most of the time, changes design intuitively. Above all, insufficient customer involvement. Customers can contribute by adding operational aspects to the main features. These deficiencies lead to the development of values that do not entirely cover the customers' needs, causing the degradation or loss of customer satisfaction as shown in Figure 5-3.

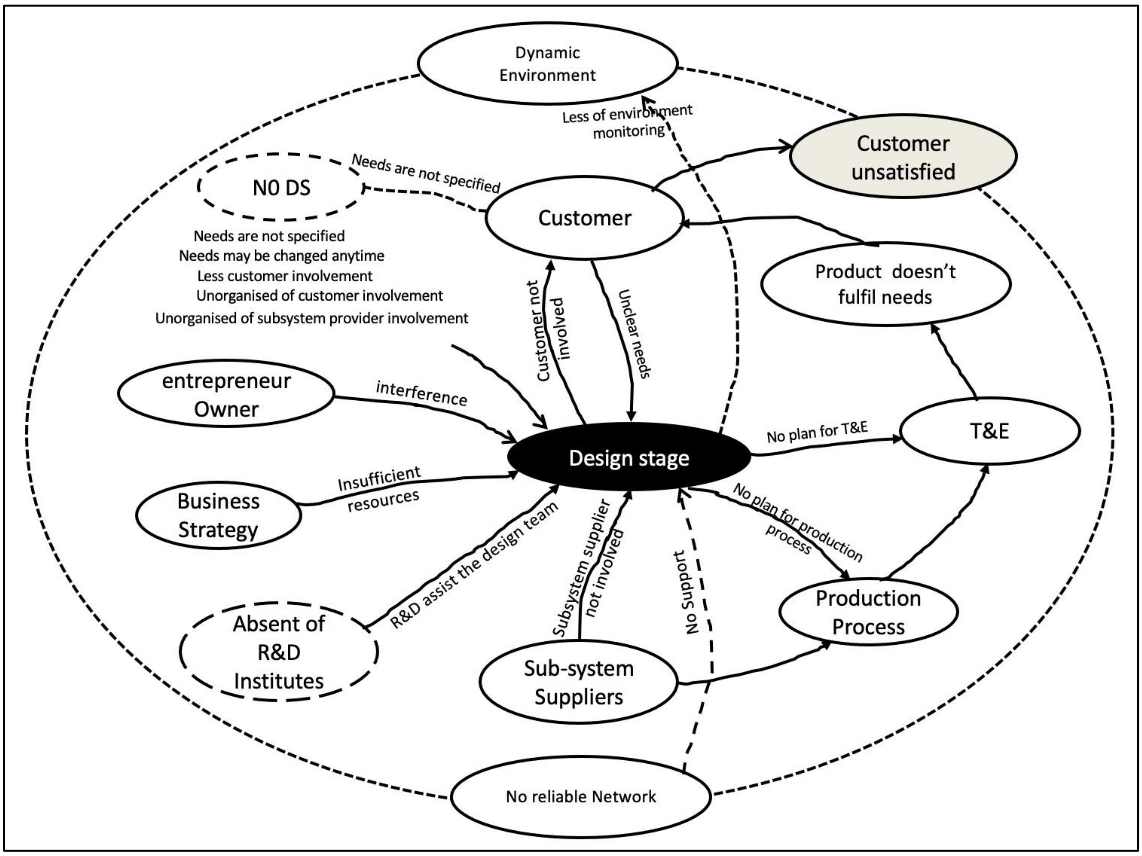

Figure 5-3. Design stage problems (Author).

T&E may also suffer from crucial deficiencies which can be summarised as follows. First, the Gulf States lack (or do not publish) defence strategies that orchestrate T&E towards a unified objective. Second, the business strategy of each system is not controlled by a defence strategy, and the strategy for T&E activities is ambiguous. Third, the design process does not involve the planning of T&E activities, and the design phase lacks highly-skilled technicians who can share their knowledge to create appropriate intermediate and final T&E steps. Fourth, there is no clear plan regarding intermediate T&E. Fifth, there is no clear plan for testing subsystems on the premises of the providers before assembly. Sixth, there is no reliable network that offers a third-party T&E with sufficient coordination between the systems, and an R&D institute. Seventh, there is no evidence of building a prototype for low-mass-production (LMP) to apply the necessary T&Es. Eighth, T&E is performed in an arbitrary manner, or without the use of appropriate statistical tools. Ninth, there is no evidence of SE tools being used to plan and execute the T&E. Tenth, there is no evidence of a clear plan to involve customers and subsystem providers.

5.3.2.2 Stage two: Construct a rich picture

The objective in this stage is to elaborate a rich picture of the real problem described in stage one (Figure 5-4).

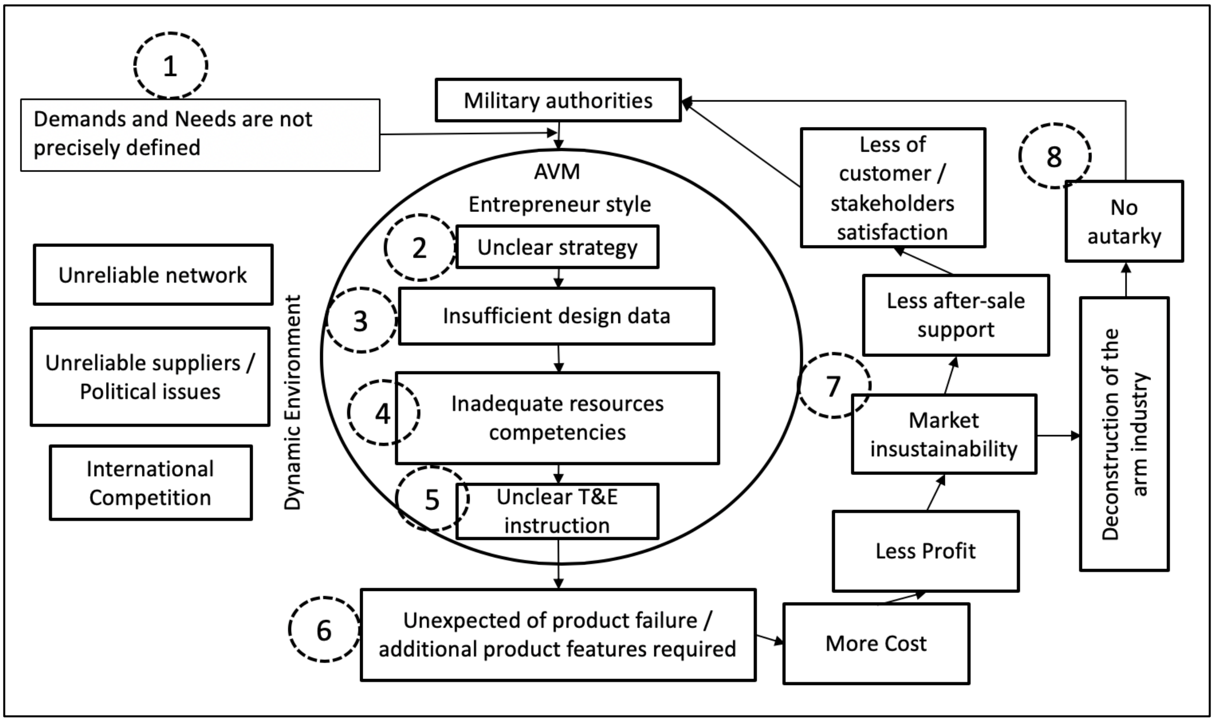

Figure 5-4. Stage two: A rich picture of the problems facing AVMs in the Gulf States (Author).

The rich picture of the problem facing AVMs in the Gulf States can be described briefly in eight points. First, demands are based on unclear needs. Second, the business strategy is not well prepared because the environments have not been scanned in a systematic manner and the strategy is not given enough attention. Third, the design phase is not fed with adequate information, lacks the involvement of key player, and does not benefit from the application of pre-tested tools or sufficient human and capital resources. Fourth, productivity is low due to the lack of competent technicians who can create competitive advantages. Fifth, T&E has many shortages in determining standards and accessing the appropriate tools. Sixth, the final product needs rework either due to deficiencies during the development process or the incomplete incorporation of customer needs in the early phase. Seventh, the consequences of producing deficient products include higher costs, less profit, market instability, and customer dissatisfaction. Last, the consequences at the national level will affect the national defence industry and will delay the achievement of autarky.

5.3.3 Stage three: Formulate root definitions of relevant systems of purposeful behaviour

AVMs are influenced by several critical players which can be defined using the CATWOE (see Table 5-5). Their behaviour alters the performance of the AVMs and the root definition of the strategic process can be set out as follows:

AVM entrepreneurs (Owners) and management (Actors), to stay in the market and satisfy their Customers, must set an appropriate strategy (Transformation) that deals with the dynamic environment (Environmental constraints). The formation of such a strategy may require the views of many key players (Worldview), such as subsystem suppliers, military customers, functional management, and enterprise workers. The dynamic strategy should be aligned with the industrial strategy (Transformation) which is derived from the NDS and must be constantly and closely monitored and executed by competent resources (Actors) prepared earlier by the management.

Customer	C	Military agencies, worker, management, owners
Actor	A	Management, military authorities, management of suppliers
Transformation	T	Insight all effected factors (external and internal) to produce a dynamic strategy that cope with the environment changes
Weltanschauung / Worldview	W	Supplier management, military customers, functional management and enterprise workers
Owner	O	AVM entrepreneurs/owners
Environmental constraints	E	Dynamic environment: all circumstances including the defence strategy

Table 5-5. Critical players influencing the performance of GCC-AVMs defined according to the CATWOE system (Author).

5.3.3.1 Stage four: Develop a conceptual model (human activity systems)

The conceptual model (Figure 5-5) encompasses the human activities needed to gradually improve the overall system of the AVMs in line with the strategic aspects. The human activities include (1) Individuals representing military authorities establish and publish an appropriate NDS to control the industry, based on their needs. (2) AVM owners and management build their business strategy based on the NDS. (3) All human activities related to AVMs that are responsible for the development of essential values are mentioned. (4) Customers must interact with the development process to enhance the output. This involvement must be organised to satisfy the needs of all stakeholders.

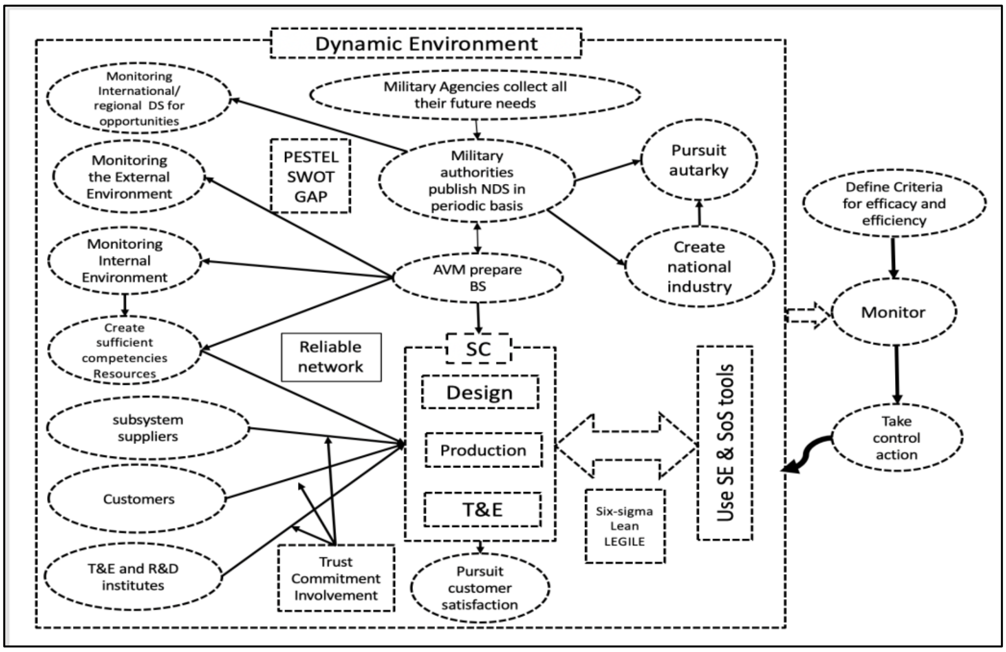

Figure 5-5. Conceptual model of the AVMs needed for SSM stage four (Author).

5.3.3.2 Stage five: Compare the conceptual model with the real world.

During this stage, the proposed conceptual model (from stage 4) is compared with the current real-world situation to recognise the strategic and operational gaps and to determine the modifications and corrective actions required to fill them. This stage clarifies "*the differences between what happens in reality and the logical model that raises the questions that will ultimately lead to change*" (Burge, 2015). Indeed, the conceptual model plays a significant role in underlining issues that were discovered by surveying different opinions and worldviews but might otherwise be ignored by the AVM management. Table 5-6 compares the real world and the model, and shows the potential corrective actions. This process is repeated to gain more worldviews, thus yielding another conceptual model that can be compared with the updated real-world situation in an iterative learning cycle.

Conceptual model activities	Real-world activities	Potential correction actions
Military agencies collect all of their future needs as the basis for creating the necessary defence strategy and defence industrial strategy which, in turn, would enhance the AVM's strategy	Needs are collected instantly Needs are not represented accurately	AVMs must insist on having a NDS to list the future needs at an early stage. AVM management should discuss with the military authority the benefits of having the needs ready for future product development. AVM management may strive to teach the users how to state their needs.
Military authority issues NDS on a periodic basis as the main guidelines for a successful enterprise strategy	The Gulf States lack a clear NDS and DS	AVMs' owners and management must claim to have periodic NDS for the benefit of national defence industry prosperity and eventually to reach the desired autarky.
The AVM management continuously monitors all environmental changes	AVMs' entrepreneurship style fails to analyse all of the effective factors, which leads to a non-reliable strategy being created The absence of the DIS leads to a weak strategy being created	AVM owners should encompass all of the effective factors when they planning their strategy. AVM management should encourage all employees to participate in setting the strategy. AVM management should strive to acquire the adequate competencies that have the necessary ability to deal with the dynamic environment.
Involve all stakeholders in creating a dynamic strategy	Not all stakeholders have an opportunity to share their views, possibly due to the AVM's policies or network weakness The management sometimes diminish the importance of some stakeholders in setting the strategy. The worker and suppliers of the system are examples	AVM management may invite all parties that benefit from their output to participate in an integrative strategy.
Monitoring and controlling the dynamic strategy	Industries sometimes rely on an obsolete strategy that is inconsistent with the dramatic changes in the environment	AVM management may have certain policies for closely monitoring any immediate changes in the environment AVM management might acquire competencies which allow them easily to seize opportunities and withstand threats AVM management should continuously and closely monitor their nearest competitors
Continuously monitor the production performance	Measurement criteria is unavailable	AVM management may set some criteria to monitor their performance. This would certainly show the progress of strategy accomplishment as well as enable them to take the necessary action to remedy any strategic deflection instantly.
• The national authority establishes a defence	• Arbitrary prediction of the future needs. • Wait for orders	• The defence strategy must be presented and published on a regular basis

strategy on a regular basis to indicate their future needs • Customers' needs must be clearly documented • AVMs must plan to educate their customer on how to decide their needs	• Adopt an off-the-shelf strategy • Attempt to contact customers • In cases of immediate orders, AVMs allocate all of their resources to performing the task • Keep resources idle sometimes as a standby for an immediate order • Designer revises the product's technical drawing with the customer	• Customers must have adequate knowledge to decide their needs
• AVMs review the supply strategy to decide who will be the provider • Adopt a partnership strategy to ensure suppliers' involvement in designing the main product • Prices for the subsystems must be constantly reviewed to decide on constant prices, at least for the near future • Select suppliers from countries that have a good relationship with the AVM's country • Plan T&E for the received subsystem parts prior to assembly	• Assign alternative suppliers from different countries • Seek new supplier for each project • Continuously scan the market • Use experience to test the system integration	• AVMs must have a supplier selection policy • Suppliers must participate in designing the product • T&E must be dedicated to accept the receiving part to ensure their integration • The AVMs' country must build a good relationship with developed countries to facilitate the flow of parts • AVMs must seek state-of-the-art parts to pursue the latest technology
• AVMs must establish a design team that can convert the needs into requirements and then into values that satisfy the customer • AVMs must plan appropriately for customer and supplier involvement • AVMs must plan continuously to educate their employees with updated technologies that will enable them to achieve the intended core competencies • AVMs may empower their employees to share decisions • AVMs may hire ex-military individuals • AVMs should plan for the rework process • AVMs may adopt a TQM program	• Hire two or three designers in the design department • Hire technicians with low skills as a fitter where the shop manager monitors/ control everything • Allocate resources based on projects in progress • Customers visit the shop-floor any time they wish/there might be sudden alterations	• The design department must encompass all functions • The production process must be designed during the design phase with adequate participation of the enterprise's various functions • Customer involvement must be planned appropriately to include all development processes • Human resources must be empowered • Defects must be reworked instantly • The core competency must be revised and controlled for sustainability • TQM is essential for AVMs
• AVMs must analyse their competition on a regular basis. • AVMs must determine their costs correctly to decide the price	• Try to reduce the burden costs to offer prices below those of the competitors • Try to understand the customers' needs and offer exactly what they need	• Enterprises must decide in which market they will compete • The costs must be understood • The value for money principle must be reviewed
• AVMs and the defence authority must decide to create a reliable network • The defence authority may invite the R&D centres to participate in detecting deficiencies and possible solutions to them	• Mutual agreements between AVM and different entities that provide R&D and T&Es • R&D is limited to the design phase only	• The defence authority must create a reliable network that consists R&D, T&E independent entities. • R&D centres must participate in developing values needed by the national military organisations
• Entrepreneurs must pay adequate attention to all circumstances that affect their performance	• Continue with the intuitive management of projects and resources	• Owners must continuously review the external and internal environment to hone their strategy
• Struggle to use appropriate tools to enhance the productivity, reduce lead time, mitigate risks and reduce wastes	• Perform traditional way to manage the supply chain without using verification methods	• Use SE and SoS methods
• Prepare and publish	• Customers cannot describe their needs	• AVMs should claim for an NDS to

comprehensive NDS • AVMs must include all customer needs and easily can convert them to requirement and specification	• No NDS to specify the needs • Customers are not involved in the design	understand the future intentions of the military authorities for the coming years • AVMs must educate their potential customer on how to list their needs. • AVMs might hire ex-military individuals who can understand the military language (slang) and may advise the customer on some requirements
• Prepare a business strategy to meet the changes in the environment • Prepare a business strategy that build the needed resources (competitive advantages) and equip them with updated capital resources • Encourage innovation within the enterprise • Encourage involvement of Customer & subsystem provider	• Business strategy doesn't prepare the required resources for the design department • Business strategy doesn't support the design team with updated design tools • Business strategy is not dynamic in ensuring an updated design along with environmental changes • Business strategy doesn't encourage customer & subsystem providers involvement	• The business strategy may prepare the design team to capture opportunities based on the state-of-art technology. • Business strategy must help management to accommodate the design department with the most updated design tools • The business strategy must open the avenue for customer and subsystem providers to participate in the design phase. this encourage for innovation
• The design team must compose of qualified individuals (real designer) with updated resources and tools • Design team must include various functions to help the designer to plan for production process and T&E process and standards. Moreover, these technician may help in design the technical parts. • The customers and subsystem providers may be involved in the design phase.	• Design department composed of 1 or 2 designers (draftsmen) • Using engineering drawing software which is insufficient for innovative design	• The enterprise must hire qualified designers with adequate and updated skills related to designing software • Form a design team composed of different skills from the enterprise, customer, sub-system providers, etc. • The design phase may be interfering with the local R&D • Design team must be updated with contemporary knowledge and training
• The design team must design the product, the production process and resources, as well as the necessary T&E process and tools	• The design department task is limited to designing the product only	• Management must design the process to include designing the product, designing the production process and designing the T&E processes and standards. • Use the SE tools and TQM which guide management to acquire effective design section
• The design team may use beneficial tools that enhance the design process and output. The author strongly recommends the design team to use QFD, DFSS, SSM and others	Not applicable	• AVM may educate their individuals on using tools of SE and TQM • AVM may hold workshops with customers in TQM and system thinking tools
• Defence authorities should publish a clear strategy which determines the needed products based on the customers' needs and concise requirements • NDS regulates the defence industry practices, including the T&E requirements	• No product requirements are published regarding T&E	• Understanding needs leads to specify requirements and standards where the T&E can be designed. • The T&Es standard may be reviewed in periodic basis and published by the NDS. •
• The design phase must consider the T&E process and determine precisely the accepting /rejection criteria. • The design team must involve different skills and experts from the production line who understand the process and product features well. • The design phase may invite the customer to determine the	• The design phase does not involve planning and instructions regarding the T&E process.	• Design team must invite technicians from the production line to plan the T&E process and help in setting standards • Design team may include operational individuals, ex-military individuals or customer to determine the operational standards.

operational criteria		
• Intermediate T&E is very important in the developing process, in which it needs intensive attention from all concerned parties before conducting the final test. • Technicians throughout the production line must be sufficiently qualified to discover defects before the next production stage. These technicians should participate in the product design • Intermediate T&E requires special tools for inspection	• Intermediate T&E is applied incorrectly because it is not planned in advance. • Technicians working on the production line may discover arbitrary defects, some of which are not remedied until the final test. • Technicians are fitters who insufficiently skilled to discover some defects. • Lack of high-tech instruments to scan for defects during assembly.	• The design team must specify the milestones where the intermediate tests are performed. • Customers may be invited to participate in in-process T&Es to shorten the final T&Es. • Technicians must be educated to perform the T&Es at any time and stage. • Using correctly the six-sigma entails some intermediate T&Es
• The appropriate selection of the subsystem suppliers tremendously helps enterprises to override some of the necessary intermediate tests. • Involving subsystem providers in the design phase enable designers to establish an appropriate intermediate test plan	• The sub-system suppliers may not be selected probably and their delivered parts may not be suitably tested before installation. • Subsystem suppliers do not participate during the design phase. • The integration of the subsystem and the whole system are not tested until the final stage.	• Management might set selection criteria to ensure receiving quality parts after have been tested by the providers. • Invite the subsystem providers to set the necessary T&E for their parts and help in testing the already assembled vehicle. • The independent T&E entity may help in testing the subsystem before assemble them into the main vehicle.
• DS must insist on producing a prototype and low rate of production as a part of the development tests	• AVMs do not usually produce a prototype to be tested or plan for a low rate production to test the same patch of the product in a different environment.	• The acquisition process may be designed to include testing the prototype and another test which perform to small number of vehicles (low rate).
• Tests should be equipped with the most up-to-date tools and means correctly to test and evaluate the product either during the production phases or in the final stage.	• Most tests are performed traditionally or arbitrarily, without a plan. • The test tools are insufficient to execute a comprehension test. • The statistical tools are rarely used as an evaluation means	• Test & evaluation are two process. • Tests must be performed in systematic way with predetermined and programmed process and standard • The evaluation must follow the test by using the most appropriate evaluation tools to easily decide the acceptance or reject the product • These tools must be known to all corresponding parties. • AVMs must use the most modern tools to get precise results which can determine the product acceptance.
• The defence authority may build qualified facilities that ensure that the required tests are carried out. • A third party, specialising in T&E, may be established privately or by the government. This third party might be an R&D institute with a T&E division. • The existence of a credible network may help to complement the AVMs' efforts by offering T&E bodies with highly-qualified instruments, labs and well-designed, different terrains	• Most of the AVMs lack test fields and facilities for testing vehicles in different terrains. • T&E Third-party is not available	• AVMs can build their T&E field • AVMs can agree together to build a field that can be used by any AVM • The T&E field must be constructed to correctly simulate the real terrain.
• The final test must be a combined effort by all corresponding parties. • The final T&E must be held in a location that has been prepared earlier for such a purpose. • The final T&E must be planned correctly to reflect the product's actual performance. • T&E must be carried out by	• The final T&E is disorganised and too poorly performed to reflect accurately the gap between the design and the real product. • If tools and instruments exist, they are not implemented, or implemented poorly. • The final test design is not included in the design phase • The final test is carried out by the developers and the customer separately.	• The final test must be performed by all parties in a well-designed process and predetermined standards. • The final test may include numbers of the same product

qualified individuals who possess the technical experience and intuition to enable them to detect defects.		
Producer representatives must make multiple follow-up visits to the operational field in order to monitor the product's performance during its operation, as part of the T&E plan.	• The product is not monitored by the developers during its various real-life operational situations, in which some scenarios were not covered during the design phase.	• The life-cycle test must be performed in different times to examine the capability of the product after a time.

Table 5-6. Comparison between conceptual and real-world activities, adapted from *Burge (2015)* (Author).

5.3.3.3 Stage six: Define changes that are both desirable and feasible

An organisation is a "*live*" system with limited resources, so the implementation of any changes differs from one organisation to another based on its ability to deliver feasible performance and the willingness of the management to perform such actions based on their strategic intentions. Hence, only the management understand the availability of resources and know if a particular change is feasible or not. On the other hand, management cannot influence the desirability of change, especially in a dynamic environment, where resources must be monitored and updated continuously. Table 5-7 highlights the desirability and feasibility of the corrective actions proposed in the rightmost column of Table 5-6. However, AVMs presumably have no choice regarding the desirability of the correction action even if such actions promise to improve performance. Accordingly, they may struggle to allocate the resources needed to achieve feasibility.

AVMs must insist on having a national defence strategy to identify the future needs at an early stage	D	F
AVM management should discuss with the military authority the benefits of having the requirements ready for successful future product development	D	F
AVM management may strive to teach the users how to state their needs	D	F
AVM owners and management must claim to have a periodic defence strategy for the benefit of national defence industry prosperity and eventually to achieve the desired autarky	D	F
AVM owners should encompass all effective factors when they plan their strategy	D	F
AVM management should encourage all employees to participate in setting the strategy	D	F
AVM management should strive to acquire the adequate competencies and necessary ability to deal with the dynamic environment	D	F
AVM management may invite all parties that benefit from their output to participate in an integrative strategy	D	F
AVM management may have certain policies for closely monitoring any immediate changes in the environment	D	F
AVM management might acquire competencies in order easily to seize opportunities and withstand threats	D	F
AVM management should continuously and closely monitor their nearest competitors	D	F
AVM management may set some criteria to monitor their performance. This would certainly show the progress of strategy accomplishment as well as ensure that the necessary action is taken to remedy any strategic deflection instantly	D	F
Continuously monitoring the environmental strategic changes using (SWOT, PESTEL, GAP)	D	F
AVMs must plan to educate their customer on how to decide their needs	D	F

Table 5-7. Changes required and whether they are desirable (D) and/or feasible (F) (Author).

5.3.3.4 Stage seven: Take-action to improve the situation

The *take action* stage demonstrates the potential solution by building a dynamic systems model, which illustrates the "*Solving Situation*" (Rodriguez-Ulloa and Paucar-Caceres, 2005). This stage requires the application of sensitivity analysis software, which is beyond the scope of this research. However, a tentative model can be proposed (Figure 5-6) to improve the current situation, which ensures customer satisfaction. Once again, this is another learning cycle.

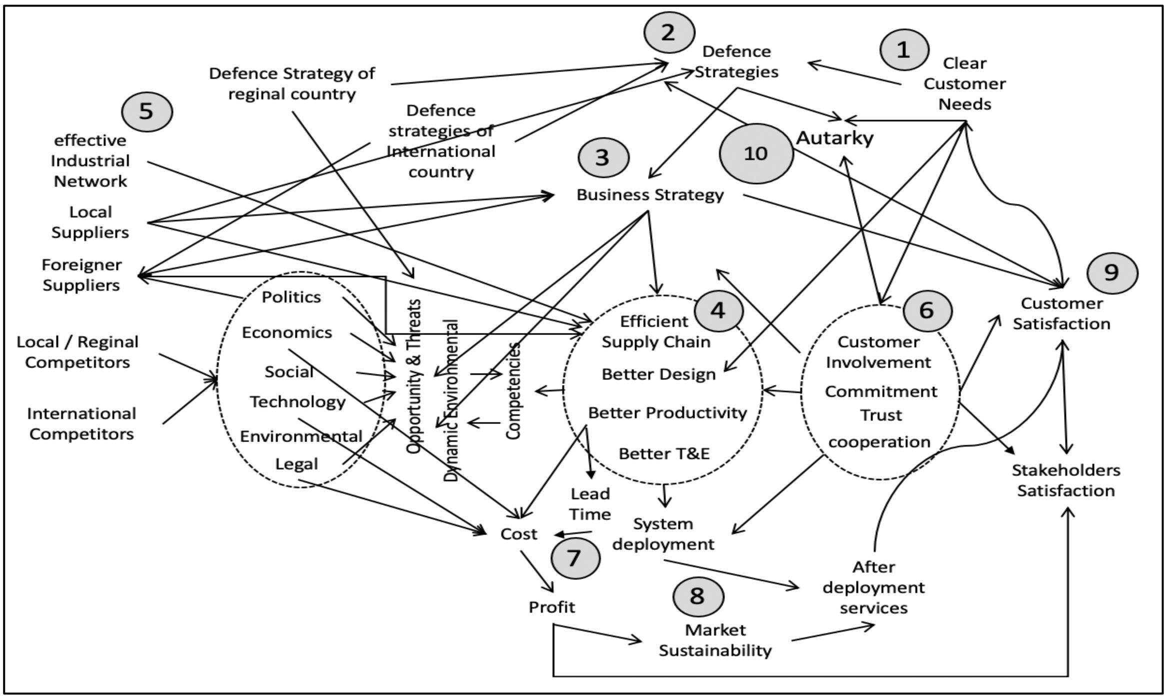

Figure 5-6. Solution causal diagram addressing the problem situation (Author).

This is the last stage in the SSM that describe the sequences of correct practices to ensure better development. The crucial elements in this diagram are the clear customer needs (point 1) and the availability of the defence strategy (point 2). The availability of the defence strategy and accurate reading of the external and internal changes results in a reliable business strategy (point 3). On the other hand, clear customer needs will feed the NDS with the real needs and enhance the manufacturer's design phase with better information. This must be followed by the creation of a reliable supply chain (point 4) and a reliable network (point 5) with appropriate interactions and involvements between the essential elements, especially the customer and subsystem suppliers (point 6). The supply chain must complement the productivity of the AVM to ensure minimum waste and an optimum lead time (point 7). Better management of the supply chain will reduce risks, costs and the lead time. The outputs of this diagram are customer satisfaction (point 9) and national autarky (point 10).

In summary, this section uses Checkland's SSM to analyse the case study elaborated in this thesis, resulting in a set of solutions that can be applied to the problematic situation facing AVMs in the Gulf States. This methodology will be compared to the conceptual model of the thesis to highlight the advantages of the latter in solving the problems of AVMs. The next section will discuss the issue by referring to data collected by other methods mentioned in the research methodology.

5.4 Discussion

5.4.1 Introduction

In this thesis, three main methods have been used to collect data: auto-ethnography, a literature review, and surveys. Each method contributes significantly to achieving the research objectives, separately and complementarily. The section 5.3 reviewed and analysed the data and used SSM to show the ability of SE tools to integrate the management aspects required for customer satisfaction. The integrative literature review (Chapters 2-3) covered the topics relevant to the research objective. The literature review produced the thesis conceptual model (section 3.8) which guided the author to construct the questionnaires, conduct interviews with key informants and arrange site visits at several AVMs. However, the author's experience, before undertaking this research, included many visits to different manufacturers and debates at various management levels, with further visits conducted during the research period. The thesis has been configured based on the military product development process, which needs attention from the defence authorities, an influential manufacturer's business strategy, a robust supply chain with a reliable industrial network, competent resources and production processes, and well-organised relationships between the developer and its stakeholders, particularly the customers, in an SE perspective. The research considered the customers as central players because they represent two actors: the legislator, who should setup a defence strategy, and the user, where customer satisfaction is the target. The following sections discuss the strategic aspect and the supply chain, broken down into its main functions: design, productivity and T&E.

The research has highlighted the importance of the strategy aspect as the prime factor when planning to achieve the required level of customer satisfaction. Both parts of the strategy, namely the NDS (which includes all national military hierarchal strategies) and the AVM's business strategy, are crucial to each AVM as they guide their resources to develop the precise values that approach the intended goals. On the one side, the customer (the military organisation) establishes and publishes the NDS which determines their exact needs in the near future. On the other hand, the AVM's business strategy can plan the AVM's activities and resources to fulfil the customers' needs. Moreover, the NDS must declare the future national vision and encourage national AVMs to contribute towards this. Because visions cannot be realised in the short term, the NDS may guide local AVMs to decide their long-term business strategies, which will undoubtedly place their current and upcoming activities alongside the periodic declarations in the NDS. Synchronisation between the NDSs and each local AVM business strategy ensures the widespread prosperity of the domestic defence industry and the sustainability of each AVM's market. The NDS may underline the facilities offered to industry to help them trade and to encourage outsiders to join the local industry. The following sections discuss the two strategy types (NDS and BS) and their importance in enhancing customer satisfaction.

5.4.2 Strategic Aspect - The contribution of the NDS to customer satisfaction

The literature review highlighted some issues that military authorities in developing countries, including the Gulf States, should consider when creating an advanced industrial environment over time to strengthen national defence capabilities. One of the primary stimuli is the possibility that countries such as the USA will place sudden restrictions on the supply of arms due to political issues. For example, Turkey, Brazil, South Africa and others have previously been subjected to arms embargos imposed by the USA. Some developing countries have therefore established their own industrial capabilities and these countries already possess a remarkable market share of arms exports. Furthermore, some of these countries have recognised that the imported arms do not precisely fulfil their unique needs, requiring them to make expensive modifications to ensure efficient performance in their specific environment. This was emphasised in the literature review because the defence capabilities and needs differ from one country to another, and each country must prepare its defence strategy after considering all national needs in order to enforce their defence means. The empirical study of this research comparing developed and developing countries revealed some crucial issues that must be addressed by the defence authorities.

The NDS is required to enable each Gulf State to enforce their defence capabilities with predefined plans, and to empower their relationships with other countries, especially those that share common interests (like the other Gulf States). Indeed, the plan must be led by reviewing the emergent threats and future potential military operations, which are routine tasks within organised military forces. These revisions often detect shortfalls that must be covered by the acquisition of new means, upgrading existing means, or sharing resources with other countries via cooperation agreements.

The NDS is a crucial set of documents that defines the willingness of military authorities to fulfil the national goal, i.e. promote the national defence industry and achieve autarky. Most western countries (with mature industries) encourage international manufactures to bid by establishing a local setup, which conducts business on behalf of the larger organisation. The local setup requires a highly skilled and readily available workforce, thus creating jobs and supporting the economy. On the other hand, developing countries establish policies that direct international suppliers to work with local industry to help them develop their skill base so that gradually they reach a stage where they can support local needs independently. The literature review supported both approaches. In the UK and USA, the best systems to suit customer needs are acquired from international manufacturers, as long as they can demonstrate that their product will contribute to the local economy. In contrast, Turkey, Malaysia, India and Indonesia clearly demonstrated how their policies directed international bidders to work with local industry to gradually achieve self-sufficiency. Saudi Arabia has declared their intention to achieve arms self-sufficiency by 2030, by encouraging international industry to establish partnerships with local government organisations and thus meet local needs (KSA, 2016). Also, the UAE has recently followed such movement and decide to create a defence strategy (Trade Arabia, 2018). The main thrust of their strategy is to industrialise in specialist defence manufacturing and to provide for the local workforce by a policy of upskilling.

Cooperation among the Gulf States is needed now more than ever because the threats are dynamic and the financial resources are becoming scarcer. The literature review introduced some examples that help Gulf States to cooperate with each other, in turn enhancing each country's defence capabilities. Cooperation between European countries has resulted in many advantages such as lower development costs (economies of scale) and greater innovation as more ideas are generated from different countries. European countries have succeeded in distributing their products among different nations based on each country's best capabilities. However, this attempt also has some disadvantages. For example, some countries may lose specialised knowledge related to a product that has been developed by other nations. Knowledge sharing is therefore required to ensure that all cooperating countries gain the same knowledge and specialisations. Moreover, products with a higher production rate (such as vehicles) may be more profitable than products with a lower production rate (such as aircraft), leading to inequalities that must be addressed when production is distributed to different countries. The relationship among the Gulf States facilitates durable, robust cooperation that fortifies the defence industry across the entire region.

The literature review and interviews confirmed that current civilian manufacturers in the local region could share the defence industry by extending their operations to include partial or full military equipment. The experiences in these factories could help the defence industry achieve independence more quickly. Turkey provides a positive example of such transformations, where the government offers facilities to empower civilian manufacturers and urges them to form partnerships with overseas companies that have acquired state-of-the-art technologies. The local government can encourage cooperation with other countries and reach long-term agreements with (1) developing countries to establish initiatives that allow them to access state-of-the-art technologies, (2) regional countries to increase the cooperation in all fields, and (3) other countries to increase export possibilities. They can also help domestic manufacturers to establish a reliable industrial network that consists of third-party establishments, such as R&D institutes, T&E providers and subsystem suppliers.

Finally, the ability of customers to explain their needs is the most critical issue affecting product development. It is therefore necessary to educate users, giving them the ability to scan operational needs and transfer them to their superiors to be included in the next NDS. Furthermore, military organisations can enhance the local defence industry by elevating their maintenance to the highest level, i.e. manufacturing. According to Kurç and Neuman (2017), there is a high probability that military technicians will perform reverse engineering on vehicles containing new technology is very high, which will gradually increase their knowledge and experience eventually to the level of the developer. This technology transfer enhances domestic industrial capabilities.

The influence of the NDS on the defence industry is therefore a key factor driving later success. The NDS can (1) guide local AVM business strategies by setting their future business plans and the necessary resources, (2) illustrate the facilities offered to enable the local AVMs to enhance their businesses, (3) establish reliable local, regional and international networks, and (4) improve the relationship with other countries for positive cooperation, technology exchange and increased exports. These contributions lead to the production of values that satisfy local customers (who initially published the NDS). This is made clear in the conceptual model (section 3.8) and the SSM (section 5.3) revealed the issues of the connection between NDS and customer satisfaction, which passes through many steps, including correspondence between the NDS and the AVM business strategy, a reliable supply chain supported by the defence authorities through the NDS, and close relationships between all stakeholders, such as the military, AVMs, subsystem providers and third-party institutions. The business strategy, supply chain and relationships among the parties are discussed below.

5.4.3 Strategic Aspect - The contribution of the business strategy to customer satisfaction

The business strategy indicates the ability of each AVM to deal with the external and internal environment and satisfy their stakeholders, particularly customers. AVMs in the Gulf States exist in a dynamic environment that requires constant monitoring and preparation to address evolving situation. The complexity of the environment is exacerbated by the SME status of AVMs and their ownership by entrepreneurs.

Entrepreneurs, including AVMs owners, tend to deal with different events intuitively, on the spur of the moment, and accept the corresponding risks (dynamic environment). It has already been proven by the literature review that entrepreneur practices besides applying essential strategic tools ensure resource flexibility in order to deal with the dynamic environment. Such an approach requires the acquisition of competent human resources with the ability to read the environmental changes accurately and act accordingly. Furthermore, the literature review and surveys suggest that AVM management should adopt a systematic, strategic process to encompass all environmental circumstances, especially evolving ones, and prepare a consistent and robust strategy. This type of strategy is not considered as a high priority in AVMs being SMEs owned by entrepreneurs.

SMEs like AVMs managed and owned by entrepreneurs could be affected by factors such as the environment, culture, location, and the characteristics of individuals and companies. Many authors in the literature review have claimed that entrepreneurs ignore environmental scanning and depend on instinct to understand the relevant factors, and then decide and act accordingly where their outputs are not clear. SMEs may differ in that all strategic analysis is undertaken by the owner, which is the case for the majority of the AVMs in the Gulf States. For example, the entrepreneur thinks he can see what others do not see (insight) and discover what their customers need without prior analysis. This type of entrepreneurial approach may lead to success, or it may lead to disaster. Hence, managing the enterprise with a solid foundation of previous analysis is not a choice but a critical requirement, which is the case when the time is very short.

The literature review illustrated the impact of strategic analysis by using the most popular tools (such as SWOT and PESTEL) in the development of an AVM strategy, which are easy to be used by AVMs' management if all effective circumstances are included, unlike entrepreneurs' practices. Moreover, the survey and interviews confirmed the need to examine the dynamic environment on an annual basis and during critical environmental changes. The informative outcomes environmental scanning (SWOT and PESTEL analysis) in the UAE and Saudi Arabia, where most of the GCC-AVMs are located, is demonstrated in Appendices H and I.

SWOT and PESTEL analysis are needed to capture the current situation and to predict the future environment before competitors gain an advantage. Opportunities (new needs) may emerge at any time and the AVM management should be prepared to capture such opportunities which allow them to develop new values before others. Evaluation of the current situation will enable AVM management to prepare the next business strategy or at least alter the current strategy to cope with emergent conditions.

AVMs require what is known as dynamic entrepreneur's capabilities (DECs) to cope with the dynamic environment by scanning the environment and acquiring the necessary capabilities. Moreover, DECs are the key to increasing the ability of AVMs to deal aptly with the dynamic environment by capturing opportunities and repelling threats. DECs may combine entrepreneurship attributes, where risks and innovations are adopted alongside the management of dynamic resources. This type of application can also elevate resources to cope with the evolving dynamic environment, even if the enterprise is an SME. However, most AVM technicians in the Gulf States possess low-level technical skills and the turnover rate is high, which affects the long-term strategies, dynamic capabilities and accumulated experience of AVMs. The management of AVMs in the Gulf States therefore cannot depend on these resources when creating their business strategy. This must be resolved by acquiring national technicians, encouraged by the NDS or other national legislation. These issues were reported by the key informants and respondents to the surveys.

The NDS can influence the business strategy of AVMs in many ways. First, the NDS can encourage local innovators to join the defence industry as entrepreneurs, but with a clear vision and systematic analysis of strategic issues (this can be achieved by legislation). Second, the NDS may provide key information to reduce uncertainty and enable AVM management to plan their future activities more effectively. On the other hand, the NDS publisher needs to understand the strategy of AVMs, which can be presented clearly in the mission statement. This is critical to all stakeholders. Indeed, information exchange between interested parties can mitigate the risks and encourage the preparation of an accurate strategy that guides the AVM management to overcome any immediate changes in the environment.

5.4.3.1 Preparing the business strategy

As stated above, the environment surrounding AVMs in the Gulf States is dynamic so management must optimise their dynamic competent resources by applying a robust strategy. The literature review advises the management of enterprises to create agile resources to cope with dynamic changes by selecting a fit strategy, reviewing earlier crucial events, and continuously and centrally reviewing their strategy to address further environmental changes. This orientation might not apply to AVMs due to low technician skills. However, most of AVM respondents stated that an appropriate business strategy enables the optimisation of resources, allowing the company to compete locally, regionally and internationally and fulfil its goals. This achieves a competitive advantage that allows the enterprise to share the competition at different levels and in different regions. The literature review claimed that such enterprises need to gain distinctive core competencies that perform better than their competitors in the selected region. These capabilities must be associated with the ability to discover opportunities before others by making continuous revisions of the dynamic environment, as occurs clearly in the entrepreneurial practices. These capabilities are limited to the higher management whereas technicians are not able to acquire such capabilities due to their limited knowledge.

The most appropriate strategies to cope with a dynamic environment are the differentiation and cost leadership strategies. Differentiation is innovation, and the latter is more suitable for continuously evolving needs, helping to capture customer satisfaction especially in unstable situations. Differentiation is associated with innovation and leadership, and if innovation cannot support differentiation, then the enterprise cannot sustain its market share due to the lack of competitive advantage. The strategy of Adoption in AVMs requires competent resources at all management levels and functionalities which are not currently present. Besides, appropriate arrangements with various subsystems' providers must be made to perform differentiation at the same time with the minimum developing costs. On the other hand, cost leadership is a strategic model in which enterprises strive to manufacture products at lower costs than their nearest competitors. This may harm the enterprise by hindering technological advances, the risks associated with imitating cost-leadership practices by new market entrants, and the lack of customisation. The cost leadership strategy is suitable when prices are a priority especially when military customers are suffering from a lack of financial resources; however, quality is compromised. Switching between differentiation and cost leadership is required which emphasises the dynamic complex environment that AVMs are always facing.

To understand how different AVMs operate, one needs to understand how creativity and innovation are managed to result in a value that benefits the customer. The generation of new ideas by AVMs is necessary to counter new threats, and this is the role of an entrepreneur who can seek opportunities and then innovate to bring value to all stakeholders. Bujor and Avasilcai (2016) have defined this situation as an engagement in a creative entrepreneurship, with a balance between artistic creativity, economics and business development side. Bujor and Avasilcai (2016) add that the creative entrepreneur deals with strategic realisation, organisational design and leadership, where ideas are turned into successful products. The entrepreneur creates and develops the business using their own competencies, capabilities and resources (Maltsev, 2016). However, these competencies must be complemented with appropriate planning and systematic practices.

Finally, the involvement of various AVM personnel with different functionalities is essential because each department has requirements and limitations that the future strategy must accommodate. However, this involvement may not be useful in all cases, especially (1) if low-level technicians lack the competence to add significant value to the strategy and (2) if management find it easier to prepare the strategy at the upper level because the owner controls everything. Nevertheless, a strategic plan can facilitate the acquisition of suitable resources (human and capital) for product development, including design, production and T&E. The strategic plan also can plan for stakeholder involvement throughout the development process, determine different measurement criteria including productivity benchmarks and T&E criteria and measurements and the interaction with potential stakeholders.

Although an essential tool of strategic management, AVM management does not typically consider mission statements as a component of their business success. **Error! Reference source not found.** shows the missing components in each mission statement currently presented by AVMs in the UAE and Altadreea from KSA. The AVMs have not aligned their mission statement to reflect their real-world mission and targets. The management teams should therefore periodically review the company mission statement to reflect their performance and goals, which will present a more convincing picture to stakeholders, who share the same SoS.

	Streit	Mahindra	Al-Asbar	Nimr	Al-Tadrea
Customers	X	X		X	
Products	X	X	X	X	X
Markets					
Technology	X			X	X
Concern for survival, growth and profitability					
Philosophy	X	X	X	X	X
Self-concept		X			
Public image					

Table 5 -9 Components of the mission statements for AVMs in the UAE (Author)

Last, In terms of the SoS concept, each system (AVM) requires a "*coordinating strategy*" to determine a strategy that benefits all of the constituent systems (Barnes *et al.*, 2017) and deals optimally with the dynamic environment by establishing a reliable supply chain. In addition, the empirical study clarified some points with regards to the willingness of AVMs in the Gulf States to compete with similar AVMs in the developing countries. First, AVMs in the Gulf States wish to have an NDS that covers essential enquiries needed for successful product development. Second, the NDS of developing countries is critical to AVMs in the Gulf States because the AVMs must ensure the flow of parts from primary providers located in developing countries. Third, AVMs in the Gulf States prefer to serve local customers, and also wish to have a clear relationship with them. Last, AVMs in the Gulf States are in a greater need of a reliable network, which must be a priority for national defence strategies.

5.4.4 The contribution of the supply chain to customer satisfaction

There is a direct relationship between customer satisfaction and the quality of the AVM supply chain, which forms the SoS network. Shamout (2016) defines customer satisfaction as the delivery of enhanced value to customers via an appropriate supply chain, in which the company must interact with customers wisely by exploiting available information to ease the flow of materials and deliver the required value on time, at an acceptable price, and with sufficient product quality. This definition has led the author to focus on the supply chain as a prime element to deal with AVMs' SoS network.

This thesis examines some of the mechanisms by which AVMs ensure customer satisfaction despite the risks facing SMEs in a dynamic environment. A reliable supply chain is one such approach, and perhaps the most important, because it concerns all of the stages related to product development. Accordingly, "*supply chain management is the management of relationships in the network of organisations, from end customers through original suppliers, using key cross-functional business processes to create value for customers and other stakeholders*" (Lambert and Enz, 2017). Therefore, an effective supply chain needs a network that includes all stakeholders, helping to provide the best value in terms of delivery time, competitive price, and product quality, thus fulfilling customer needs. Supply chain management is therefore an excellent risk mitigation strategy (Kamalahmadi and Parast, 2016). However, such an approach requires numerous efforts shared by all constituents' elements especially when one concern is presented in SMEs organisation.

AVMs in Gulf States face high demand, but they may fail in future if their production output falls below the required level or demand is averaged or reduced due to competition or changes in the environment. A robust supply chain is therefore needed to deal with the current and future dynamic environment. The literature review demonstrated that a robust supply chain is required for self-reliance:

1. Create a reliable network that includes all entities that add value to end product. This requires the integration of: (1) internal resources (2) subsystem providers, and (3) customers.
2. Acquire suitable dynamic resources.
3. Adopt agility, robustness, and resilience strategies.

5.4.4.1 Reliable network

A robust supply chain network must be planned to mitigate risks in the dynamic environment associated with unexpected actions from customers and subsystem suppliers. Additional risks are generated by wasting resources, which extends the development process thus increasing costs and lead time. A reliable network gains control of the customer, subsystem providers and internal human resources through exchanging necessary information and knowledge during planned interactions in the form of involvement, commitment and trust.

The integration of internal human resources reveals the degree to which different departments with different functionalities work together efficiently in a collaborative, coordinated and organised manner to achieve better value thus leading to customer satisfaction. Communication and integration among different functionalities and departments should be decided as part of the preparation of the enterprise business strategy. This approach offers many advantages to the AVM business: first, information shared between departments (such as design, production and T&E) will enhance the performance of each department as well as the AVM's overall output. AVMs are SMEs with a flat structure, allowing them to plan for efficient communication and information exchange. Second, the involvement of shop-floor technicians in the design team during the early stage of the development process enhances the technical integration of different subsystem parts and the production process. Also, the involvement of T&E personnel in the design phase helps the design team to factor in appropriate and timely tests for subsystem parts and the product. Moreover, the T&E personnel can improve the design by indicating the testing criteria or tolerances. Communication among these departments is discussed below in relation to the design and T&E steps of the development process. Third, continuous and pre-planned interactions among individuals with different skills can facilitate the evolution of the knowledge inside the organisation and enhances the learning cycle.

As revealed by the literature review, customer integration helps AVMs to build strong relationships between the internal and external entities of the supply chain network with potential customers and main subsystem suppliers, adding significant value to the organisation and thus increasing its innovation capabilities and competitiveness. Stakeholders' participation during the design phase has the following advantages: (1) all customer needs (latent and overt) are accommodated, (2) the production process design includes recommendations from production technicians, and (3) appropriate advice is provided by subsystem providers. AVMs derive the following direct benefits from customer involvement: (1) the customer brings operational experiences into the design team to match technical features with relevant operational situations in an innovative manner, (2) customer representatives can identify product issues that are incompatible with intended operations, and (3) the customer can be involved in T&E, which increases confidence in the product and thus overall satisfaction.

Some AVMs have hired ex-military personnel due to their valuable and desirable technical and field experience. These individuals possess knowledge that can be utilised to communicate with military customers and quickly understand their needs. Customers always wish to meet ex-military personnel because the interactions are more comfortable due to their shared military language and experience. Hiring ex-military personnel may help the customer more than the AVMs, but the AVMs may benefit from such personnel by enriching the operational features of the product.

Finally, the selection of subsystem suppliers is critical, particularly because AVMs depend to a great extent on suppliers from different countries when the flow of materials is affected by political issues. Subsystem suppliers can contribute substantially during the design stage, with input equal in status to the design team. The coordination achieved by integrating subsystem suppliers streamlines the exchange of operational, financial, and technical information with the development team. The integration of knowledge from AVMs and their subsystem suppliers (1) facilitates a collective decision-making style, (2) enhances the features and functionality of particular parts because specialised suppliers know about their parts better than the main product developers, and (3) contributes to better inventory management. Based on the questionnaire responses and interviews, AVMs favour the JIT system (please refer to question 30) for supply chain management because it enhances the relationship with their subsystem providers and reduces costs. Moreover, the location of enterprises also influences the supply chain (as mentioned in the literature review and approved by the questionnaire responses), and so the location of AVMs. However, this effect was not clearly recognised in the questionnaire responses and interviews because it is a strategic decision. The location of AVMs in the UAE was a strategic decision that was taken by the owners based on the geopolitics of the Gulf States. Finally, subsystem providers can contribute to T&E, particularly in terms of how their parts integrate into the larger system to create a high-quality product.

5.4.4.2 Acquisition of dynamic resources

The enterprise business strategy must establish a robust supply chain by allocating its human resources and capital resources wisely, i.e. by allocating resources that can deal efficiently with changes in both the external and internal environment as part of the supply chain. The literature review explained the importance of flexible resources as a means to mitigate risks inherent in the dynamic environment, particularly where companies seek competitive advantages. It has been approved through the literature review that the dynamic capabilities of a company (as a vital part of supply chain management) are strongly linked to innovation, which can be embedded in a resources-based review (RBV) to ensure static resources become dynamic. Dynamic capability and innovation allow companies to learn to enhance their performance and thus develop new ideas to address continuous environmental changes. Innovative enterprises thus adapt better to environmental changes and innovation allows AVMs to differentiate their products based on customer-specific needs by acquiring competent resources. Such resources cannot innovate without management support, a suitable structure, and sufficient empowerment and reward. Moreover, the inclusion of local R&D institutes in the industrial network can also enhance overall performance. Such institutes can help to solve problems and introduce new products based on innovative ideas.

Operating in dynamic environments requires an entrepreneurial mind-set, which embraces a certain amount of risk acceptance and risk management, as well as innovative approaches (Lanza and Passarelli, 2014). However, such risk must be continuously encountered and mitigated to enable AVM to continue their business to serve their customers. Pure entrepreneurs may harm the business unless systematic management is adopted as the management skills which have a remarkable influence on the production line, especially in complex environments. Entrepreneurial management skills have a remarkable influence on the production line, especially in complex environments. The entrepreneurship style of AVM management encourages innovation, and due to the flat structure of such organisations it is possible to empower employees for innovation purposes, which will gradually improve dynamic capabilities. These advantages must be controlled wisely besides adopting the entrepreneurship practices. AVM management in the Gulf States therefore have the ideal conditions to create dynamic resources that (1) develop new values to deal with emergent threats in the region by innovation, (2) depend on local technicians to keep knowledge within the country and establish the foundation for a domestic industry which ultimately achieves autarky. Local competent resources can also join international AVMs hosted by the Gulf States to elevate their skills and support the local industry and (3) communicate fluently with local customers to encourage interactions among entities and increase network reliability by enhancing trust. Local technicians have more commitment to national interests.

5.4.4.3 Adopt agility, robustness, and resilience strategies

The agility, robustness, and resilience strategies can be achieved by companies adopting dynamic capabilities and a well-organised structure as described above. Agility is required to deal with the dynamic environment by mitigating risks caused by unexpected fluctuations in demand and supply due to political issues and/or the unreliable behaviour of stakeholders. The literature review introduced the Leagile strategy to overcome some of these demand and supply risks and optimise the AVM productivity. Lean management and the six-sigma approach can reduce project down time (which affects lead times) and material waste (which affects costs). These are the main objectives of certain supply chain management practices that optimise productivity. One question posed in this study was can AVMs in the Gulf States apply such management practices, given their status as entrepreneur-owned SMEs? The questionnaires and interviews suggest the answer is yes, for some reasons. First, the processes rely on three main elements: customers, production personnel, and suppliers. The production (AVM) is in the middle, which plays a coordinator role between the customer and subsystem providers. The production process (regardless of size) will be efficient if AVMs can always coordinate the flow of incoming suppliers and predicted demand. Such coordination requires a high level of interaction and information exchange to build a reliable SoS. Such coordination is more likely to be strong in local networks controlled by higher authority, i.e. the military. Second, If AVMs can achieve dynamic capability then their internal resources can be considered agile, robust and resilient. AVMs can then coordinate with their customers and subsystem suppliers efficiently.

However, the current situation requires AVM managers to have a strong influence on the supply chain compared to technicians. Managers (often owners) try to control the entire enterprise because (1) the workshops are small and (2) technicians are mostly low-skill workers that require continuous monitoring and instruction. AVM managers must therefore acquire more technical and management experience in order to manage the development process efficiently. Moreover, ex-military managers can add value to products based on experience of military operations, which complement the technical aspects of the product features. Ex-military managers can communicate with military customers more fluently than civilian managers.

Based on the above, the dynamic capability of a company in terms of supply chain management has a significant impact on customer satisfaction by different approaches. For example, a well-designed supply chain reduces development costs and production lead times while enhancing productivity, which improves customer satisfaction. Second, collaboration within the supply chain enhances the relationship and information flow between the three main parties: the developer, subsystem providers, and customers. Third, adopting a flexible (agile) supply chain enables the enterprise to reallocate resources instantly in response to the dynamic environment. For example, the enterprise can quickly accommodate changes in customer requirements, which enhances customer satisfaction. In another example, an enterprise with agile resources can capture opportunities and convert them to innovative values that exceed customer expectations and thus achieve customer satisfaction. Last, collaborative supply chains accommodate different forms of integration among entities with diverse functions. This brings all the stakeholders together in a closer relationship that benefits customers and enhances their satisfaction. Moreover, each member within the network struggles to satisfy their customers if some of them are other enterprises with other customers.

5.4.4.4 Supply chain as a system of systems

SE offers many tools to help design an organisation, and its internal processes, as well as other entities within the same supply chain, to perform well in a dynamic environment. Each enterprise within a supply chain network can be considered as part of a SoS (Choi, 2018) given that each constitutes a system that is operationally and managerially independent, with evolutionary development, emergent behaviour (because each constituent never reaches its goal separately), and geographic distribution. Each of these constituents can improve its supply chain by adopting the

SoS and systems thinking approaches. SoS principles that apply to AVMs include objectives, control, structure and uncertainty.

The objectives can be used to optimise the incentives for each system. AVMs can work alone without planned coordination, and the objective might be approached. But this would neither be as effective nor as efficient compared with the SoS concept, in which all constituents within the network help each other to optimise their objectives (a win-win situation). The control ranges from decentralisation, where each system has its own control, to a situation in which all of the constituent systems are under central control that strives to achieve the overall goal of the SoS. The national goals specified by the government become the main incentive to form a network of different entities that work together to achieve these national goals, while each body still works independently to fulfil their individual goals and contribute to the national ones. However, high-level coordination is necessary to achieve control in this model.

The structure of the supply chain is dynamic in the sense that each of the system's constituents selects the appropriate supply chain members that complement their performance. A weak system might be reinforced by other members to promote the advantage of the supply chain. Therefore, AVMs as a part of a network must evolve to react like their co-entities against sudden environmental changes, collectively working to achieve the national goals efficiently and effectively. Last is the uncertainty where the risk aspect of SoS is the accumulation of risks that face each of the system's constituents, and robust risk management is required. Risks that affect one system can spread out to include all systems within the network and thus all systems should become aware of current risks by enhancing the flow and exchange of information. For example, fluctuating customer demand is a high risk to AVMs and will also affect subsystem providers, so special arrangements and coordination are required to mitigate such risks.

The creation of a network with predefined goals set by a higher national authority can help AVMs, as a part of the network, to satisfy their customers and contribute to national goals. A reliable supply chain network encourages information exchange among its constituents, which in turn mitigates the risks of a dynamic environment. The supply chain in each system involves different organisational subsystems (departments) each of which can add value to the system and thus the SoS. At the same time, each department is affected by changes in the SoS. The influence of the dynamic environment on each department is discussed below.

5.4.5 The contribution of the design concept to customer satisfaction

The conceptual model in this thesis shows the dynamic environment faced by AVMs and the design phase is placed to show how the other elements either affect or are affected by this phase. The design phase is strongly influenced by antecedents such as the NDS and enterprise business strategy. Customers, subsystem providers and other stakeholders also have a significant influence on the success of the design process. The design department represents a system that is affected by other systems and thus provides another example of the SoS concept. These systems must be managed properly on an individual basis and then integrated to work towards a single objective.

There are numerous management practices that can enhance the design phase specifically and the development process overall. The effective control of product development (which avoids defects arising during the manufacturing process in the dynamic environment), the design team may use DFSS methodology as part of the six-sigma approach. Applying DFSS as a customer-oriented tool to the existing design process can enhance customer satisfaction by improving quality, reducing lead times and/or reducing production costs. In this regard, it can be argued that AVMs should devote more of their resources to the design department to create a competent team of individuals with different skills, and should equip them with adequate design instruments. This would be appropriate if the AVMs were to form a core competency group in order to realise a competitive advantage.

5.4.5.1 The design dilemma for AVMs in the Gulf States

AVMs in developing countries are relatively new compared with similar entities in other parts of the world. However, this is changing due the demand from surrounding countries for different means of protection against new forms of threat. AVMs in developing countries have responded in an arbitrary and inefficient manner yet exceed expectations. During production, although such arbitrary practices appear in different parts of the process, they are concentrated during the design phase during which the design team determines the features and functions of the end product.

The rule of thumb is that if management promises customers a good product, they must fulfil their promise. For example, the mission statement, as a part of the business strategy, is a statement of the enterprise's promises to their employees and their customers, which represents their performance in terms of the values they deliver. These values are decided during the design phase. Although the enterprise's business strategy has a significant impact on performance (including the design phase), AVMs in the Gulf States rarely present their business strategy to their customers.

The literature review highlighted the importance of defence strategies in defining the future needs of troops: (1) the preparation of defence strategies requires commanders to raise their needs with the higher military authorities, which gradually enables users to define their needs in a specific way; and (2) defence strategies have a significant impact on the business strategies of local AVMs, which allocate resources on the basis that the local military are the primary customer. This was confirmed by the key informants interviewed in each AVM. The absence of an NDS in the Gulf States may affect the design process, and thus the entire development process, because this strategy guides all national parties, and encourages regional and international parties, to coordinate with each other to develop products with values that match national interests.

The design team is responsible for selecting the subsystem parts sourced from abroad, especially from countries with uncertain political relationships with the host country. The selection criteria for subsystem providers must be revisited periodically. The industrial network can add significant value to the product, especially during the design phase. The literature review revealed the need to establish a design team that represents all the functionalities in the enterprise. The sharing of different functions during the design phase helps to avoid problems that might emerge later during the production process. The principle has yet to be embraced by most AVMs in the Gulf States. The involvement of different functions during the design phase requires high-level technicians with the ability to add value to the product design, production process and T&E. The involvement of employees during the design and development phases enhances the enterprise's performance, but such involvement depends on their qualifications (skills) and commitments. The AVM respondents confirmed the need for high-level technicians and qualified employees to share their thoughts with the design team and implement their ideas during the production process. Knowledge sharing within the enterprise improves product design and can lead to a competitive advantage (Christian Homburg, Schwemmle and Kuehnl, 2015).

Customer involvement during the design phase correlates strongly with customer satisfaction. The problem with limited involvement is that most customers are not fully aware of all their needs, especially latent ones. The management and marketing teams may identify some of these needs in meetings with customers, but other needs may be overlooked unless the customer is competent enough to explain their real needs directly to the design team. Moreover, the importance of prioritising customer requirements must be recognised by the design team when meeting with knowledgeable customers to control development costs and optimise the product's functionality. Moreover, the involvement of the subsystem providers is beneficial because they can introduce the designers to state-of-the-art parts that improve the overall functionality of the main product. However, if this involvement is limited, then the subsystems may not integrate well into the main product, resulting in the need for further adjustment (and the waste of time and materials). Some AVMs address this by dealing only with well-known manufacturers of auxiliary parts to provide their subsystems (brake systems, suspension, chassis and armoured glass). For example, Streit has one provider for brake-systems and another for suspension-systems, and Al-Tadrea has a single provider of armoured glass.

Finally, quality assurance tools (used almost by all AVMs in the Gulf States) can ensure that all customers' needs have been encompassed in the proposed design. Using such tools not only yields a successful design but also reduces waste throughout the production process. The fact that "*Customer satisfaction and process improvement have been found to be the main reason for ISO 9001 implementation by most participating companies*" (Dongmo and Onojaefe, 2013) might deceive the customer. Thus, ISO cannot replace using the quality tools discussed in the next sections

5.4.5.2 The contribution of the PADOV process

Product development is unique for each different product, and in this context the need for specific managerial activities increases the complexity of the process

(Unger and Eppinger, 2011). Design teams should therefore follow a well-defined process that enables them to address their customers' needs comprehensively by incorporating the appropriate features (Bruch, 2012). AVMs typically face significant challenges when attempting to convert real customer needs into satisfactory value for all stakeholders in a highly competitive environment, so the design phase is important for all parties. If DFSS (as a beneficial SE tool) is applied, PADOV enables the management of any enterprise to design optimum value for their customers in both technical and management terms, including the marketing aspects (Yoon and Byun, 2012).

The following sections demonstrate the gap between current AVMs design processes and the typical DFSS (PADOV) process which, if applied correctly, would enhance the AVM's strategy, design process, and also the manufacturing process. As discussed earlier, PADOV consists of the following process: plan (P), analyse (A), define the candidate architecture (D), optimise and evaluate (O), and verify the system (V).

5.4.5.2.1 Planning the technical effort (P):

Planning can be divided into strategic and technical aspects, both of which are important for any organisation. Six-sigma (implemented as DFSS) is based on planning as the first step in a successful design process. Six sigma introduces a number of recognised planning tools (such as 3C, SWOT, strategic plans, MGPP, WBS, PERT/Gantt charts and project charters) to enable manufacturers to select the best features of a product (Yoon and Byun, 2012). Such a product would suit the customer's demand while also enhancing the manufacturer's competitive position and sustainability in the market. SWOT and PESTEL analysis have been discussed in detail and browsed in appendices H and I where opportunities and possible productions are determined to help the design team in deciding which features (requirements) are more desirable by the customers. The author, during the visits, has not recognised using these beneficial planning tools due to insufficient resources (capital and human)

5.4.5.3 Analytical requirements (A)

Needs and requirements are the backbone for achieving customer satisfaction during the development of any new product. The acquisition of real requirements depends largely on the ability of the design team to abstract the specific needs of users and translate them into requirements and then technical specifications. According to DFSS, the process is initiated simply by collecting data through market research, voice of the customer (VOC), and interviews where it is very difficult to apply the first technique with the military customers. The data are then sorted using an affinity diagram, after which the design team compares the proposed specifications to their quality history and benchmarks them against the nearest competitors. The design team can use a Kano model, for example, to test the overall satisfaction of their customers. The entire process could be assembled through a quality function deployment (QFD) process. DFSS assists the design team by recommending the use of these tools to analyse the requirements comprehensively in order to prepare for the next step. However, some of these tools are new to the designer, need effort beyond the capability of the team members and their skills, or the team feels that some tools, such as customer meetings, are sufficient to abstract the requirements. In this context, the activities of AVMs in the Gulf States can be summarised as follows. First, most AVMs use one or two marketing personnel to identify customer needs. The designer and technical supervisor contribute very little, which weakens the entire process. Second, the interviews are neither systematically planned nor carried out intuitively. Therefore, the VOC might not be completed as it should be. Third, each AVM compares its products with those of its competitors in the region. Whereas some AVMs, such as Streit and Mahindra Armour, use international benchmarking, NIMR creates its own benchmarking standards. Fourth, the benchmark for all GCC-AVMs depends primarily on the raw material suppliers. For example, subsystem suppliers control the specifications of the powertrain, armour plates and accessories. The opportunity therefore lies in the ability of the AVMs to manipulate and integrate those systems into one comprehensive product. This may introduce new benchmarking standards. Last, there is no evidence that tools such as the Kano model, the affinity diagram or QFD are used by AVMs in the Gulf States.

5.4.5.4 Define the candidate architectures (D)

This phase, which is the critical milestone in selecting the best alternative among many solutions, could be the most challenging for the design team. The design team might select a less-efficient combination of systems by applying the traditional approach, which ultimately leads to a significant degradation in the overall efficiency of the entire system and so affects customer satisfaction. Six sigma (DFSS/PADOV) advises the design team to use different tools and techniques to: (1) follow a systematic approach that enables its members to work efficiently, and (2) produces a unique system with the optimum selection of subsystems to ensure customer satisfaction (Yoon and Byun, 2012).

In addition to the belief that applying such tools wastes money and time, which is unacceptable to the management teams, AVMs in the Gulf States also avoid DFSS tools during the design phase for further reasons. The first reason is that decision-making in AVMs is limited to the top management (entrepreneurs), who usually think that they can capture the best solution intuitively. The top management always thinks that the cost of using these tools exceeds the revenue that will be gained. Moreover, the number of design team members able to apply such tools is too small. Another reason is using up-to-date design software gives the design team the feeling that the software is sufficient to acquire the best solution at a lower cost. Last, the prevailing impression regarding such tools is that their complexity leads to more problems than they solve.

5.4.5.5 Optimise and evaluate (O)

To minimise the production lead time and costs, it is essential to design for waste reduction during the manufacturing process. Six sigma/DFSS recommends several well-known tools that can be used to reduce waste, including statistical tolerance, design for manufacture/assembly, robust design development, multidisciplinary design optimisation (MDO), sensitivity analysis and simulation/design of experiments (DOE). Statistical tools are useful for the analysis of variations in the manufacturing process and the implementation of necessary remedies for both the management and the design team. For example, robust design analysis is a technique that reduces any variation resulting from internal noise (due to machine wear and tear) or external noise (due to changes in the manufacturing environment). Martins and Lambe (2013) clarify that MDO focuses the design team on the integration of different subsystems early in the design process, which improves the design and reduces the time and cost of the design cycle.

Given the prominence of quality systems such as ISO 9000, it is evident that all AVMs in the Gulf States focus on eliminating variations during the manufacturing and assembly process. However, AVM management is reluctant to use statistical tools and sensitivity analysis despite recommendations, and variations in the process and assembly are deemed the responsibility of the shop manager, who takes the decision either to continue or to rework the product.

5.4.5.6 Verify the system (V)

The last step in PADOV is to verify that the system performs as planned. The design team must define a control chart and its limitations (upper and lower) for T&E. However, the design team also assigns other limitations to determine the ability of a process to prevent a defect or detect defects when they occur (mistake proofing). Designing a test for the prototype by gap analysis allows the evaluation of system reliability, availability and efficiency, which is extremely important in the design phase. In this context, the activities of AVMs in the Gulf States can be summarised as follows. (1) There is no evidence that AVMs use control charts for T&E. (2) AVMs rely on T&E performed by the national armed forces. For example, AVMs in the UAE prepare their prototypes every August (because the temperature is the highest all year) for T&E by the Emirate Armed Forces, and a certificate is issued if it is successful. (3) The direct manager is the only person responsible for defects arising from the capabilities of the process. He uses his intuitive skills to detect any defects.

5.4.6 The contribution of T&E to customer satisfaction

The interviews and questionnaires raised some further important issues in the context of T&E. First, the absence of an NDS in the Gulf States affects the willingness of AVM management teams to consider T&E programmes as an essential aspect of the product development process. But appropriate T&E is critical, and AVMs should not ignore this, even with no NDS to enforce it. Second, the presence of different functional entities (especially third-party T&E providers and subsystem providers) adds to the value of T&E in the AVM industry. For example, the presence of AVMs and subsystem providers in the same network facilitates information exchange concerning subsystem standards and measurements. Furthermore, T&E third-party providers may play a significant role between customers and AVMs in the same network. Third, the involvement of AVM personnel with different functions during the design phase should lead to a T&E plan, especially an in-process T&E plan (intermediate T&E) that is applied in all production stages. Highly-skilled technicians (dynamic resources) can contribute to T&E tasks, but this is not yet possible in most AVMs because almost all the technicians are fitters, who depend totally on the production manager to determine their tasks. Fourth, VOC is essential for understanding customers' needs in depth and translating these into requirements. This can also provide standards as benchmarks for the evaluation of test data. However, there are two major reasons why customer involvement is not prioritised by AVMs in the Gulf States: customers are unable to explain their needs precisely, and the AVMs lack the mechanisms to control such interactions. Accordingly, AVM management should highly consider the appropriate planning of customer involvement in both intermediate and final T&E.

Moreover, the current test is performed prior to deployment by the customer alone, in a subjective manner without any clear evaluation tools. For example, the brake system of the armoured vehicle is tested in a highly conventional way, without a clear benchmark or any objective evaluation tools. The brake system of an armoured vehicle is vital for the control of mobility in different circumstances, but the current, arbitrary tests fail to cover all operational situations and certainly do not involve an examination benchmarked against objective requirements. As a consequence, the customer may accept a defective product or even reject a sound one. The hiring of ex-military individuals with useful operational and technical knowledge may help AVMs perform robust operational tests on behalf of customers, especially when the customers are unable to perform these tests themselves. The management teams of AVMs in the Gulf States prefer one or more ex-military individuals to serve on their staff, either in a consultant role or as production manager. During on-site visits, the author met ex-military personnel with detailed knowledge of the operational and technical aspects of armoured vehicles. These individuals understand customers' needs and can arrange T&E procedures that match real operational conditions. But even so, the essential objective evaluation tools are not available.

Customer involvement in product T&E is essential. Customers may test their product during the production process on the developer's premises or test may be performed at the end of the developing process either at the developer's location or at the site where the customer will use the product. The primary purpose of the in-process test is to capture the customers' evaluation of certain functionalities before proceeding to the next stage, where the corresponding parts might be hidden and unreachable to customers in the final test. For example, it is important for the customer to inspect the welding which joins the armoured plate together before it is covered by fabric or leather, while the main purpose of the field testing is to test and evaluate the whole product prior to its deployment. Therefore, it is necessary to apply T&E throughout product development, not only during the final stage (Sydenham, 2004). The earlier and appropriate planning of T&E procedures during the design phase is essential that must cover all of the production stages and ensure the programme's smooth progress to completion with minimum risk (Tribble, 2005). If one of these tests is ignored, then the program's success will be questionable. It is important to emphasise that a quality certificate (e.g. ISO) cannot replace T&E. Most customers incorrectly assume that an ISO certificate represents the quality of the product, but as stated earlier it can only certify the production process based on the manufacturers' own standards (Dongmo and Onojaefe, 2013). Thus, relying on an ISO certificate in lieu of correct T&E processes may mislead the decision making.

The involvement of subsystem suppliers, through collaborative networks, is necessary in the dynamic environment to ensure the fitness of subsystems as part of the product during the design process. The subsystem providers must examine their products before submitting them for assembly, requiring T&E to ensure their integration (compatibility) with the whole system. The nature of the SoS gives each system (the subsystem providers) the ability to operate independently, which in turn affects other systems (the main product developer). Therefore, it is advantageous if the entities collaborate in terms of both the design and the T&E aspects.

Reducing uncertainty is an aspect that highly concerns managements. One way to reduce uncertainty is to evaluate the performance of the network, wherein the success of each constituent system is a success for the entire collaborative network (SoS). The collaboration between systems within a network enhances its performance and thus its competitiveness. Therefore, the construction of a local or regional industrial network helps AVMs to complement other enterprises (systems) within the network (SoS) and to perform efficiently and effectively. The network must also include the most important enterprises, that add certain values to the SoS entire objectives, such as subsystem providers, R&D institutes, T&E providers and administration services.

Product development within enterprises is a system, which deals with various other systems in a complex environment, so the challenges of T&E can be seen in the context of the SoS model. Similarly, the AVM is considered a system that interacts with other systems, including subsystem suppliers, customer organisations and individuals from defence agencies, T&E third parties, and other stakeholders. All the entities work together in an uncertain environment to develop the product. Moreover, the AVM management deals with many systems that must be integrated according to the overarching business strategy in order to approach the goal of customer satisfaction. T&E is one component of this metasystem that must be organised and performed in the appropriate manner to develop a product that performs well.

The application of SoS methods leads AVM management teams to take account of any changes in their stakeholders' circumstances which affect the system and its constituents at different levels (Boehm *et al.*, 2012). For example, if one subsystem provider changes their product specifications, then the main system (the product) must be adjusted to avoid the failure of integration. This situation has a remarkable effect on the T&E programme for each constituent system to ensure continuing overall functionality. Thus, SoS validation involves multiple levels of T&E which should be applied first within each constituent system to verify their performance before adjusting the SoS as a whole to ensure its overall validity.

Applying the SoS concept to T&E raises many challenges, such as the broad objectives of the SoS (which reduce the importance of T&E), difficulties in controlling all constituent systems under a unified T&E programme, and the conflict of interest between the goals of each constituent system and the overall goal of the SoS (Dahmann *et al.*, 2010). These challenges can be mitigated by (1) SoS capability objectives must be assigned to a higher authority with strategic control over the entire SoS. The higher authority can impose regulations that mandate a T&E process by publishing an NDS. This would force the individual entities to apply T&E in an appropriate manner, helping to achieve the network objective efficiently and effectively. (2) Policies and requirements are designated at the systems level according to each system's capability, which forces systems to evolve in order to synchronise themselves effectively with the SoS. This includes the determination of T&E requirements and standards. For example, each subsystem provider must evolve their ability (including T&E policies) to deliver the most suitable parts for newly developed AVs. Therefore, each subsystem provider must implement its own independent T&E programme and this must be updated based on changes in the SoS (such as a new product). (3) All systems at this stage must collaborate with each other in order to synchronise T&E. For example, the AVM is the customer of the subsystem providers and must receive parts that are already tested, which requires efficient coordination between the two parties. And (4) the SoS should include an independent and accredited body that provides the tools and resources needed to perform T&E with a high level of credibility.

5.4.6.1 Applying V-model as a T&E tool

The V-model (Blanchard, 2012) simplifies the verification and integration of a system by understanding customers' needs, which specify the requirements as a detailed design in the top-down approach on the left arm of the V (Figure 5-7). The right arm of the V shows how the development of the system must accommodate the required tests in three stages: the developer's perspective to verify each subsystem, the system testing to ensure successful integration among the components, and finally the user's perspective, which verifies the system against operational requirements.

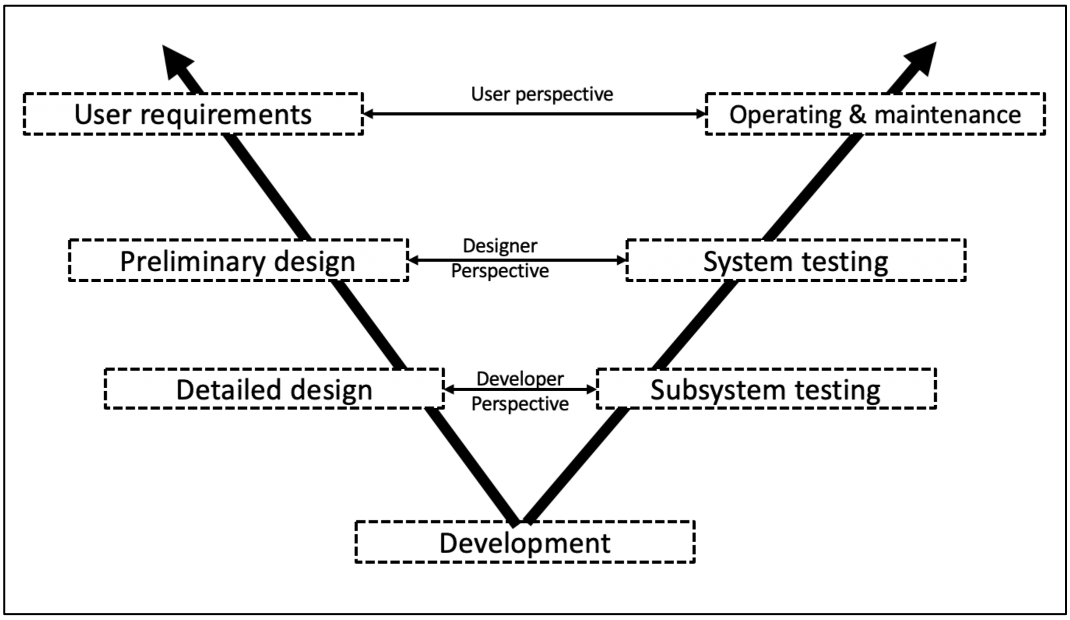

Figure 5-7. Contribution of the V-model to system evaluation (Blanchard, 2012).

The V-model helps developers to verify and validate their system (Brooks and Sage, 2005) and also increases interactions with customers and subsystem providers (Weiss *et al.*, 2009). The V-model is suitable for the directed and acknowledged SoS (Vaneman, 2016) and provides the following benefits (INCOSE, 2015). (1) It reduces development risks because any deviation from the standard can be recognised earlier. (2) It ensures product quality because it compares the real-life performance with the standard at every stage of development. (3) It reduces the costs of product development and operation. And (4) it enhances communication among stakeholders.

The spiral process model can also be used to check the system at defined stages and milestones where each milestone is based on predetermined objectives and alternatives. The V-model and spiral process model are useful tools to ensure the integration of systematic T&E into product and process development.

5.4.7 The contribution of interactions to customer satisfaction

The analysis of questionnaires and interviews highlighted that the involvement of the customer and subsystem providers in the design, production and T&E phases enhances product development in a technical context. Customer knowledge, especially technical personnel with different skills representing military customers, helps the design, production and T&E teams to combine technical and operational aspects to improve the product's performance. On the other hand, the subsystem suppliers know more about the parts. Affective, continuance and normative commitment from both sides are necessary to strengthen the relationship among parties, which reinforces the trust. One way to enhance the interaction is visiting the premises of customers which leads to greater customer satisfaction. Visits by developers may foster more interactions which strengthens the trust between the parties. The proximity of the developer to the site where the product is operated allows developers collect real-world data about their product. Moreover, customer involvement must be planned at known milestones and with defined individuals based on the acquisition strategy as part of the NDS. This involvement must enhance rather than hinder the development process. Although none of the Gulf States has an NDS to regulate the relationship between parties, AVM management teams are willing to implement such a strategy to make the relationship more constructive. The lack of an NDS in the Gulf States inevitably leads to an unclear acquisition policy for AVs within military agencies. This ambiguity has led to a relationship based on suspicion, in which the AVM management team expects unpredictable actions from the military customer, which reduces the level of trust between them.

A common national heritage can significantly affect the interaction between AVMs, subsystem providers and customers. The common language and proximity among the entities promotes involvement and trust, and commitment is improved because all parties are pursuing the same national target. The national AVMs have a greater desire to serve their native customers for two reasons: the national intention and their greater understanding of the unique local environment. In this context, solving customer problems will also enhance trust. In addition to the culture aspects, arranging lectures for the customers and joining the customers in the operational field to monitor product performance can increase customer satisfaction. Therefore, customer involvement must be strictly controlled to avoid disseminating confidential information belonging to either the developer or customer. One important issue to regulate the interaction is the price setting which can affect the relationship between AVMs and their customers. If the AVM provides the requested values at an acceptable price, the customer will be satisfied. In some cases, the customer understands the cost structure of product development and the profit margin, and the final price will not adversely affect customer satisfaction even if high. However, if the customer thinks AVMs are overpricing their products because the customer has an urgent need, then the customer will be less satisfied.

5.5 Building the conceptual model

This chapter discusses in detail how AVM management teams can develop values that achieve customer satisfaction even in a dynamic environment. The value in this context is AVs produced by AVMs that are SMEs owned/managed by entrepreneurs who accept risks and adopt innovations. AVMs in the Gulf States are surrounded by a dynamic environment moulded by many factors that force the management to avoid intuitive thinking in favour of systems thinking to ensure business success. The success of AVMs in the Gulf States is strongly supported by higher authorities. These want to establish and grow the defence industry for two main reasons: to develop the national economy and to achieve autarky. To reinforce the objectives, the military authorities must intervene by publishing necessary regulations and documents to control the industry and encourage the various entities in a shared network to work together towards the defined national objectives.

Each entity, including the AVMs, in the network has two objectives: satisfying their customers and contributing with others to achieving national goals. It is obvious that a business strategy is necessary to ensure both goals are reached efficiently and effectively. The business strategy defines the AVM's mission, the human and capital resources that are needed, and the supply chain, which includes all development processes: design, production and T&E. The supply chain of each entity in a network must be designed to harmonise with those of other entities, thus enriching interactions among them by promoting involvement, commitment and trust. The supply chain elements are constantly exposed to unexpected fluctuations in the environment, beyond the planned strategy, thus requiring direct attention from the management. Moreover, the resources of AVMs must be updated based on emergent needs or the business is more likely to fail.

By considering each AVM as a system, SE methods (particularly SoS) can be applied to AVMs in the Gulf States leading to the conceptual model framework shown in Figure 5-8.

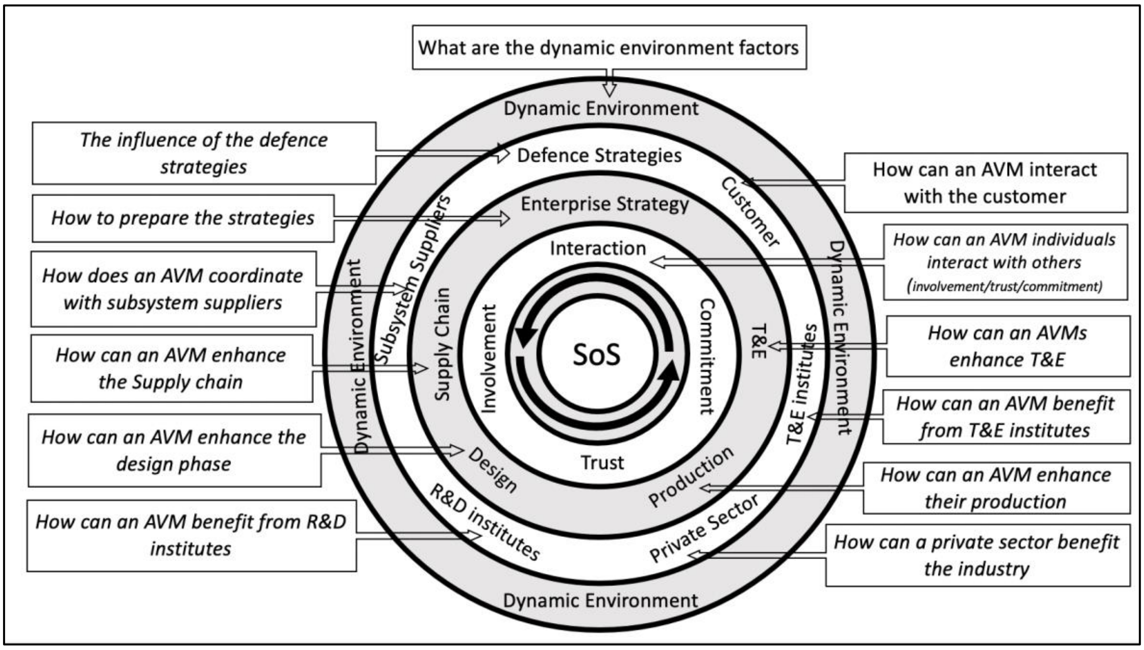

Figure 5-8. Conceptual framework model (Author).

The conceptual model is a complete steps start with the defence strategies (NDS) and end with customer (receiving the product and capture their satisfaction). Therefore, the NDS should define the goals that every interested party (local, regional and international enterprises and third parties) should acknowledge. Each party, including the AVM, should prepare an enterprise business strategy based on a periodic review of the external and internal environment. Management must pay continuous attention to any changes in the environment and must amend their strategy accordingly. The defined enterprise business strategy requires a reliable supply chain, such that the enterprise must join a reliable network and support interactions with all stakeholders by establishing involvement, trust and commitment. The supply chain also consists of prime functions, including design, production and T&E, which must be planned appropriately and equipped with competent resources to increase their efficiency and effectiveness by reducing development costs and production lead times. The supply chain plan must address all risks and should aim to mitigate them. Indeed, a reliable supply chain may be strengthened by existing entities, including R&D and T&E bodies and private sector administrative services. These factors are regularly exposed to environmental changes (reflecting the dynamic nature of the environment), which create an emergent situation that requires organisational adaptations. But each new position must once again adapt to cope with subsequent environmental changes. This dynamic process enhances the learning cycle in each organisation (system) which can be considered as part of a larger SoS. The conceptual model introduces 13 enquires (answered in this thesis) that AVM management should bear in mind as they strive for customer satisfaction and other objectives concerning national interests.

5.6 Comparing the conceptual model to SSM

SSM is a beneficial SE tool that can be used to deal with the dynamic environment by investigating different worldviews, illustrating deficiencies in current practices, and introducing conceptual solutions (section 5.8). In the context of AVMs, SSM can be applied by management to find appropriate and affordable solutions based on available resources. Although SSM can be applied to solve the problem articulated in this thesis, it has various deficiencies that can be overcome by applying the conceptual model developed as part of this study. The SSM is a long, time-consuming process that requires the collection of multiple worldviews. The application of SSM may require the hiring of specialists in both technical and managerial roles and a facilitator to obtain the necessary data and complete the associated enquires. In some cases, the root problem is not clear enough to identify appropriate solutions, so the root problem needs to be reinvestigated and redefined.

Moreover, AVMs in the Gulf States are SMEs with a concentration of skills in higher positions and a majority of low-skilled personnel, who may not be able to apply SSM. The SSM relies on the perceptions of participants rather than objective facts, so the perceptions may require more investigation and clarification which can't be covered by the existing relatively low number of resources. Also, the SSM requires the collection of information about the customer, which in the case of military customers is often unobtainable. It is also difficult to involve the key informants. Last, SSM does not focus specifically on the organisational process and its alignment with the goal.

In contrast, the conceptual model developed in this thesis has many benefits such as the model is suitable for SMEs because the owner/manager can respond directly to enquiries. Second, the model clearly identifies aspects that must be optimised to achieve the specified goals efficiently and effectively. Third, it features 13 questions, the answers to which should enhance the development process, leading to the capturing of customer satisfaction. Last, it allows each element to be revised individually.

5.7 Learning cycle to improve the performance of AVMs

The organisational learning cycle discussed in Chapter 3 (Figure 3-15) describes how AVM management teams can continuously review and re-plan the development process in a dynamic environment. Figure 5-9 shows the continuous improvement learning cycle of AVMs, which consists of four learning cycles and nine milestones that can be described in the next paragraph.

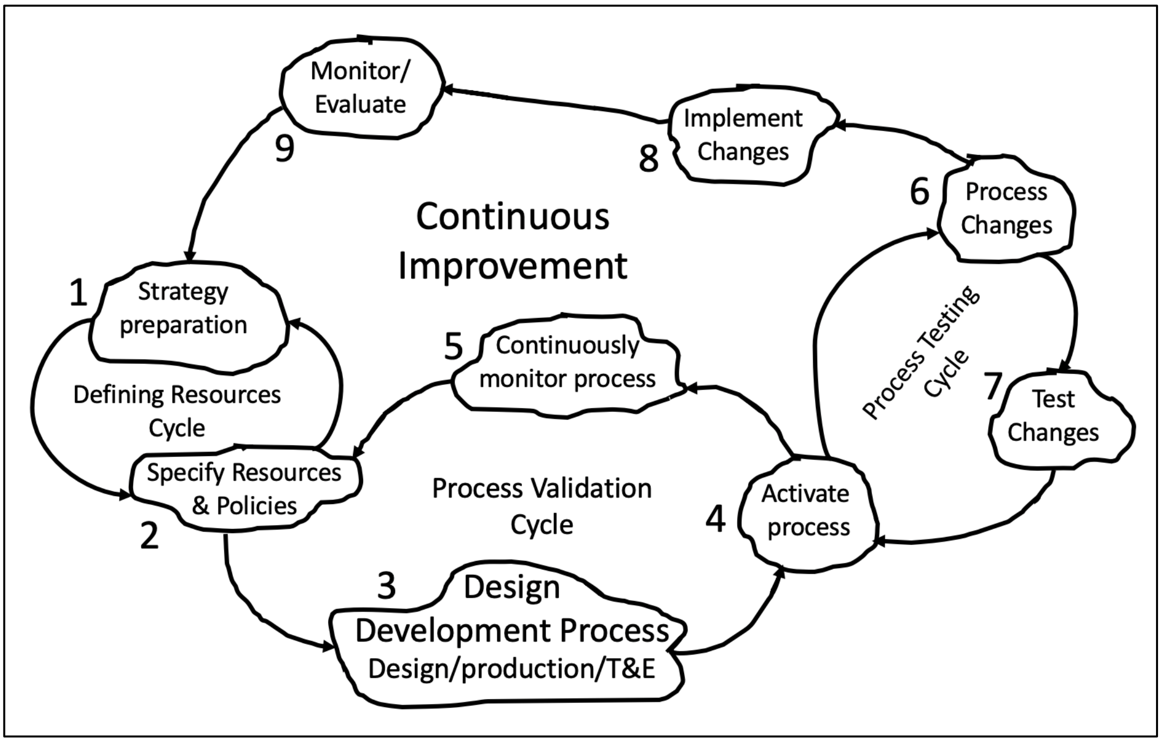

Figure 5-9. The AVM learning cycle, adapted from Barton (2014).

Milestones 1 and 2 reflects the strategic preparation (milestone 1) and resource specification (milestone 2) together form the enterprise's core competencies which must evolve based on environmental changes. Otherwise, resources remain static over time. The evolving strategy and resources create the first learning cycle: the "defining resources cycle". The second cycle is process validation cycle (milestones 3 to 5) which incubate designing the development process (design, production and T&E; milestone 3), which is then activated (milestone 4) and monitored (milestone 5). The process testing cycle (Milestones 6 and 7) is the third cycle where the process must be changed (milestone 6) when there are changes in resources and the environment, and it must be continuously tested (milestone 7) and new setups activated (milestone 4). The continuous improvement cycle is the last cycle (Milestones 8 and 9). The final changes are implemented (milestone 8), which are then monitored and evaluated (milestone 9) against the prepared strategy (milestone 1).

5.8 Summary

In this discussion chapter, the different aspects that contribute to achieving the two principal objectives – customer satisfaction and arms independency (autarky) – were considered in detail. The chapter highlighted the importance of defence strategies in the achievement of customer satisfaction by discussing the business strategy, supply chain, and the design, production and T&E phases of development. These phases can be optimised by applying SE tools, which integrate the management and technical elements, and the significant interactions among the elements were demonstrated by applying the novel conceptual model developed in this thesis. The model comprises of 13 questions, the answers to which determine the optimal approach that leads to customer satisfaction – the primary objective of this research.

6 Conclusions and Recommendations

6.1 Introduction

The defence industry is an attractive field for countries and investors alike. Countries struggle to strengthen their security against rapidly proliferating threats, and strive to achieve autarky. Investors are willing to commit financial resources to the defence industry because it is a promising and evolving industry sector. Nevertheless, the sector also faces some critical issues that hinder its progress, such as dwindling national defence budgets, the shortage of technically-skilled individuals as the field becomes more sophisticated, the fact that many defence enterprises are SMEs requiring government support, and the urgent need for international cooperation. The Arabian Gulf area is no exception. The defence industries of Saudi Arabia and the UAE have expanded, and the other Gulf States must follow. This national willingness must be combined with an NDS so that local, regional or international manufacturers can follow such strategies efficiently and effectively. Local defence manufacturers are most inclined to work towards national goals, such as autarky. This thesis considered AVMs in the dynamic environment of the Gulf States as a case study.

The exploratory literature review revealed a positive relationship between the availability of an NDS and the business strategy of AVMs which, in turn, affects the supply chain including the design concept, production activities, and T&E phase (the main stages of the AV development process). The literature review emphasised the significance of completing these steps competently to capture customer satisfaction in a dynamic environment, which can be achieved by delivering their needs and continuing to provide long-term support. Dealing with many entities requires a robust network to enhance the continuously evolving relationships between AVMs and their stakeholders, which are fundamentally based on involvement, trust and commitment. The thesis considered AVMs and their stakeholders as systems that have evolved together in a network to achieve unified goals, and SE methods are required to ensure such systems function well. In the same context, each AVM consists of many subsystems (departments) which must be efficiently (managerially) integrated to produce a system (product) which also comprises many subsystems (subparts) which again require technical integration to optimise the performance of the end product. This comprehensive approach was illustrated as a conceptual framework model, which was used for further investigation. SE methods and tools were used to optimise the functionality of each development process. Checkland's SSM was used to compare the real-world situation of AVMs against the conceptual model. Finally, the learning-cycle model was applied as a tool to continually improve the performance of AVMs in a dynamic environment. The SE tools, the thesis conceptual model and the learning cycle helped to address the research question: "*How can the managers of AVMs in the Arabian Gulf States employ their resources efficiently to deliver values that satisfy all their stakeholders, particularly their customers?*"

The analysis of AVMs in a dynamic environment required a pragmatic approach, which usually focuses on solving problems and provides flexibility in the selection and deployment of research methods. This ontology integrates the logical thinking of all worldviews related to the thesis topic. The philosophy of positivism was also adopted to extract the hypothesis from the exploratory integrative literature review, using it to construct the conceptual model and the subjects for the questionnaire. Finally, interpretivism was used to explain the empirical data and integrate the experience of the author and his colleagues with other worldviews, ultimately delivering a consensus in many of the issues covered in this study. Qualitative and quantitative methods are used sequentially based on the progress of the research towards its main objectives. The research started with qualitative methods (explanatory literature review, and informal interviews), followed by a quantitative method (questionnaire and statistical analysis), and finally the qualitative interpretation of results. Entrepreneurial practices in complex environments require more than one paradigm to cover all issues (Najmaei, 2016). These paradigms require both quantitative and qualitative methods depending on the research situation. Although some scholars have differentiated between pragmatism and interpretivism, these ontologies can be used in a complementary manner. In this thesis, the results obtained by applying pragmatism (constructive knowledge) were supplemented by the application of interpretivism to understand them. Whereas pragmatism engages in changes, interpretivism is used to understand these changes. There is a strong relationship between pragmatism and systems thinking tools (Barton, 2014) which allowed the author to apply SSM, in which explanatory interpretation is used to fill the requirements of the seven SSM stages. SSM revealed gaps in the performance of AVMs in the Gulf States and identified potential solutions. Customer satisfaction, as a prime aim of this thesis, was approached by defining three relationship pillars: involvement, trust and commitment. The thesis considered customer satisfaction as an index to understand the business success of the AVMs, i.e. their ability to provide appropriate value and the role of military and local organisations in the creation and publication of dominant strategies. The success of AVMs supports the national defence industry and promotes autarky. The thesis investigated their influence on the performance of AVMs (design, production and T&E) and product features. Thus, using SE tools facilitated the integration of AVMs with other entities, and also allowed the analysis of their products and manufacturing processes. The author used the quasi-experimental method to reveal the differences between AVMs in developing and developed countries, offering a broader area to explore and thus allowing the identification of further gaps that require attention.

6.2 Meeting the aims and objectives of the thesis

The author aims to optimise the technical processes using management tools to effectively enhance the customer satisfaction. In order to accomplish this aim, this study uses AVMs' as an example to propose a comprehensive conceptual model that enhances the integration between technical and management processes using Systems Engineering approach that enhances customer satisfaction. This aim requires the fulfilment of several key objectives (Chapter 1) which imposed the selected ontologies and methodologies and the strategy for data analysis. The objectives were addressed as shown in Table 6-1 and are discussed below in more detail.

Objective	
One	Determine the significance of the relationship between the national defence strategies and customer satisfaction.
Two	Determine the significance relationship between enterprise business strategy and customer satisfaction.
Three	Determine the significance of the relationship between the enterprise supply chain and customer satisfaction, assuming that the supply chain is related to the industry network, design concept, productivity and T&E
Four	Determine the significance of using system engineering tools and SoS in the enterprise management practices to ensure that the overall national and enterprise goals are approached
Five	Determine the significance of the interaction between AVMs and their stakeholders which activated through planned involvement, trust and commitment that lead to increase customer satisfaction?

Table 6-1. Thesis objectives and the chapters in which they were addressed (Author).

6.2.1 Objective one

1. There is no evidence for the existence of a published NDS in any of the Gulf States. Therefore, the author highlighted the benefits of such a strategy in

developed countries such as the USA, UK and other European countries so that developing countries will adopt a similar strategy if they wish to establish a defence industry that can robustly and effectively support future acquisition or capability development. Moreover, the NDS must play a significant role in nurturing the national defence industries, which will gradually grow until they achieve full independence (autarky).

2. Questionnaire and interviews: The author sought a consensus from AVM personnel responsible for strategy development. All participants highlighted strategy as a key factor in achieving successful customer relationships, especially in the case of military customers.
3. The NDS can be used to determine which facilities offered by the government enable the enterprise to deliver better value. Moreover, the NDS can help these enterprises to export their products to friendly nations.

6.2.2 Objectives two and three

1. The integrative literature review described a continuous link among the main disciplines required for value creation: the enterprise's business strategy and supply chain, which included the design, production and T&E phases. Each of these areas must be considered in detail by AVM owners and managers, regardless of the management style and size of the enterprise.
2. A questionnaire was used in this part for two purposes. First, to match the respondents' reactions with the author's hypotheses in order to identify best practices that enable enterprises to approach their goals efficiently and effectively in the dynamic environment. Second, to compare the practices of AVMs in the Gulf States (experimental group) with AVMs in other countries (control group) by applying the quasi-experimental method and the Mann-Whitney U-test. Statistical analysis revealed key issues that AVMs in the Gulf Area must address if they wish to compete internationally.
3. Checkland's seven-stage SSM was used as an SE tool to explore deficiencies in the supply chain, design and T&E phases. The author collected worldviews by conducting formal and informal interviews, and via questionnaires, phenomenology and auto-ethnography. Further analysis indicated three significant deficiencies. (1) AVM management teams do not pay enough attention to the preparation of a comprehensive business strategy. (2) The supply chain

lacks the necessary coordination with key stakeholders. And (3) the interactions between AVMs and their stakeholders are weak due to the absence of a reliable industrial network that ensures involvement, commitment and trust.

6.2.3 Objective four

The author highlighted the importance of SE in the integration of management and technical efforts to achieve unified goals. SE tools include the waterfall model, spiral process model, V-model, PADOV, SoS and SSM, enabling management to enhance their operations within a complex environment. By considering their enterprises as a system, the decision-makers (generally the owner/manager) can appreciate a range of perspectives that facilitate the reallocation of resources to achieve integration, collaboration and cooperation. These dimensions are needed to establish reliable industrial networks as the basis of a robust supply chain, leading to greater customer satisfaction. This is especially the case in B2B relationships, which was one of the assumptions made in this thesis.

6.2.4 Objective five

AVMs and their military customers have a B2B relationship which can be challenging in some cases due to the management styles of AVMs and in other cases due to the behaviour of customer organisations. The thesis discussed some of the factors that affect this relationship and its reliance on involvement, commitment and trust. These dimensions and associated elements were assessed to determine their impact on the ability of AVMs to achieve customer satisfaction.

6.3 Conclusions

Chapter 5 provides an explanatory discussion focusing on the analysis of the data collected in the integrative literature review, interviews with key informants, questionnaires, and by applying SSM. The latter enriched the analysis by providing a list of potential corrective actions, although the implementation of these actions depends on the willingness (desire) of the management and the capability of each AVM (feasibility) in terms of resource allocation. The author accepts these corrective actions as an approach to enhancing the performance of GCC-AVMs by introducing better value for customers and thus increasing their satisfaction. Moreover, these actions cumulatively form a new situation which can be considered as a stepping stone to another round of SSM when the environment changes, which is often the case when the environment is dynamic in nature. The outcome of the data analysis and discussion was a conceptual framework model associated with 13 questions, the answers to which can benefit AVM management teams by providing a path towards achieving customer satisfaction. Finally, the thesis described the benefit of continuous learning cycles, which help organisations to enhance their performance in a dynamic environment. The following sections summarise the issues related to customers and AVMs, respectively.

6.3.1 Conclusions related to customers

As this thesis has insisted in different locations, the enterprise's relationship with its customers is essential for enterprises' business success and thus the stated national targets. Furthermore, knowledgeable customers are more beneficial to the developers where the co-created knowledge is necessary to enhance the developed product in which customer satisfaction is undoubtedly captured. This encapsulates the findings of this thesis, since the customer is the centre of any business. This in turn ensures production efficiency (in the sense of quality, cost and lead time) and customer satisfaction. Importantly, the customer and defence strategy publisher from a single organisation: the military. The following paragraphs will reveal several important customer-related issues.

The lack of a published NDS among the Gulf States has many adverse consequences. The most important issue, in the absence of published NDS results, is an unclear target for the defence industry, especially when the country achieves national targets such as arms independence. Also, the NDS depicts the intention of the country's leaders to cooperate with other nations (regionally and internationally). Other nations will be more reluctant to deal with countries without an NDS. Furthermore, the lack of an NDS means that a bottom-up equipment requisition mechanism cannot be implemented in the military organisations. The lack of an NDS also reduces the interactions between military customers and their providers. The NDS usually advises all parties to engage in greater interaction and collaboration to improve the resulting products. The high-authority, through an NDS, may establish and regulate a national network (SoS) that consists of all related national entities and appeals for the sharing of regional and international networks to enable domestic manufacturers to exchange knowledge and physical parts with various overseas entities. Therefore, the NDS may guide the preparation of a local AVM business strategy as the next enterprise activities are determined by the potential military customers' needs, which are already published in the NDS. An NDS may help customers from allied countries to engage in further coordination and integration, especially among the Gulf States. Without an NDS in place, customers and AVMs alike have no benchmark for evaluating their products, because the NDS covers the acquisition process, and prescribes the equipment requirements. In the long term, fewer interactions also reduce the transparency and degrade the mutual trust, which in turn affects customer satisfaction.

Military customers in the Gulf States lack sufficient knowledge to articulate their needs (especially the latent ones), introduce innovative ideas, track the development process, and perform T&E at different stages. These competencies are needed at all development stages. Customers should be creative and innovative in order to interact productively with customer-oriented providers. Qualified systems providers are needed but it is also essential to have knowledgeable customers that contribute positively towards the development of appropriate values. Customer knowledge could be extended to include an understanding of the pricing methods and development cost structures. This thesis argues that customer involvement helps to produce values that increase customer satisfaction. In the Gulf States, this involvement is poorly-organised and requires more attention, but individual customers must be trained in order for them to reap the benefits of their involvement.

6.3.2 Conclusions related to the AVMs

The relationship between customer satisfaction and the competitive advantage of an enterprise is clear, as discussed in various locations of this thesis. AVMs must have resources with sufficient competence to gain a competitive advantage. These concepts have been discussed throughout the thesis to emphasise the need for a comprehensive business strategy and a robust supply chain that incubates the elements required to gain the core competencies. These can be used to achieve a competitive advantage which leads to greater customer satisfaction.

As mentioned above, the need for an NDS must be reflected by the AVMs and other local defence manufacturers calling for such documents to be published. The benefits of an NDS and the significance of linking it to the defence manufacturers' business strategies were outlined in Chapter 2. Most of the AVMs in the Gulf States are owned and managed by entrepreneurs, and so formal procedures for assessing, establishing and implementing the business strategy are not prioritised. This thesis emphasises the need for essential strategic principles, regardless of the enterprise's size and management style. The differentiation strategy may be the most appropriate strategy for promoting innovation capabilities. Other strategies, like cost leadership, are appropriate in certain circumstances related to customers' financial aspects. In addition, entrepreneurs can adopt strategic entrepreneurship to enhance the enterprise performance and ensure a competitive advantage.

The business enterprise strategy requires the acquisition and preparation of the resources that are necessary to cope with a dynamic environment. As stated earlier, internal resources should be developed into core competencies, i.e. resources that are unique, cannot be imitated, and have evolved based on environmental changes. Otherwise, they will be rigid (core rigidity) and unable to respond to environmental changes. AVMs concentrate their core competencies in terms of human resources on the upper levels of management, whereas the lower-level personnel tend to be low-skilled technicians (fitters). Highly-skilled technicians are needed for their contribution to the design phase (involvement) and ability to detect deficiencies throughout the production process. Moreover, these technicians can innovate and propose new ideas. Innovation requires skills with continuous learning which can be achieved by applying the learning cycle principles as discussed in the literature review and one of the SSM outputs. High-level technicians are required to cope with the dynamic environment.

Most of the supply chain for the AVMs in the Gulf States is unclear, at least to the author, and this may reflect the fact that SMEs lack the knowledge to manage their supply chain as their resources are limited. However, a resilient (a combination of robustness and agility) supply chain is essential in an unpredictable environment that involves intense rivalry.

The author has recognised several key points related to the supply chain that remain unclear within the current practices of the AVMs in the Gulf states. First, managing a supply chain involves the creation of a conventional supply chain network which relies on sufficient integration, cooperation and coordination among the participants. This thesis discusses how these three elements can be promoted by interactions in the form of involvement, trust and commitment. The network was considered as an SoS, where each system works independently to fulfil its own goals and cooperatively to achieve the overall network goals. Competition exists between networks rather than between enterprises. Moreover, the defence authority may help to construct a reliable network comprising all of the essential entities, including third-party T&E providers and R&D institutes. Second, demand risk and subsystem supply risk have a considerable impact on supply chain efficiency. Demand risk can be mitigated by planned coordination with customers. The national defence industry can also help by advising on future demand. On the other hand, subsystem supply risk can delay system deployment and thus reduce customer satisfaction. However, a network featuring the proper coordination of suppliers (partnerships) will reduce this type of risk. Third, the adoption of lean and agile management practices can help AVMs to create a robust supply chain. Other management practices should be considered by the AVMs in an appropriate environment. Fourth, productivity is essential for achieving customer satisfaction. The lack of this measurement in the AVMs in the Gulf States reduces the ability of management to control the development costs and market prices, thus reducing the likelihood of customer satisfaction. Last, the presence of ex-military individuals as consultants or shop-floor managers can add significant value to the supply chain. These individuals have the ability to communicate fluently with military customers and quickly understand their needs.

As depicted through this thesis, the product design process is essential for enterprise performance as the former must involve designing the development process in addition to designing the product. Therefore, the AVMs must recognise the impact of this process on customer satisfaction. The thesis discusses the design concept elements and which factors must be considered in order to develop a product that fulfils the customers' needs. The design of AVs requires highly-skilled designers, state-of-the-art knowledge and technology to produce value that can withstand the latest threats and compete against the AVMs from developed countries. The contribution of the customer and subsystem suppliers is required to determine the operational needs and best subsystem components, respectively. On the other hand, the contribution of in-house technicians during the design phase can add specialised (innovative) ideas to the new product and also facilitate the design of an appropriate assembly process. Those technicians are responsible for integrating the different components along the production line. Lean management is adopted to reduce the lead-time and production costs, leading to results that capture customer satisfaction. The thesis proposes to adopt a Leagile system to mitigate the demand and supply risks and guarantee the above two dimensions. Managing production is not the responsibility of the owner as it involves the collective efforts of all involved personnel, who participate jointly in designing and executing the production process.

T&E reduces the number of defects within products, thus reducing the costs and lead time and thereby enhancing customer satisfaction. The author believes that T&E is paid insufficient attention by many AVMs. Moreover, the interviews revealed a lack of awareness about the benefits of T&E, suggesting that the AVMs often underestimate or overestimate the performance of their products. AVM personnel generally feel that T&E incurs costs without tangible benefits in terms of revenue, so they are unwilling to commit effort to this process. The involvement of customers and subsystem providers in T&E is critical, and the degree of involvement depends on the development stage. For example, it is important to involve customers during the T&E planning so that they can contribute their experience when selecting the operational tests and locations. In contrast, the subsystem suppliers must be involved when deciding when, where and how the subsystem parts will be tested prior to assembly. T&E requires close coordination and cooperation among the systems that make up an SoS to ensure the success of the overall system. Moreover, a third-party T&E entity could be involved in the planning and subsequent implementation of all or part of the T&E. The presence of a T&E third-party entity within the network is beneficial because this helps customers and manufacturers to plan and execute professional tests. However, the local defence authority may organise test events on an annual basis and invite local providers to introduce their newly-developed vehicles for testing. This offers two benefits for customers: (1) they can browse all newly-developed products; and (2) they can examine all new products based on a unified test to draw valid comparisons between them.

As stated earlier, T&E consists of two main parts: testing the equipment and analysing (evaluating) the test data. This thesis argues that evaluation, in most cases, is more important than testing, and thus requires more attention. There are many tools and software packages that facilitate reliable evaluation, thus guiding the decision-makers regarding whether to accept or reject the tested equipment. Last, it is important to recall that T&E is different from ISO and other accreditation certificates. Some manufacturers use ISO accreditation to convince their customers of the quality of their products. However, customers who are aware of the difference between ISO standards and T&E objectives might be put off by this approach. The AVMs must be more aware of the drawbacks of relying on ISO accreditation rather than applying the necessary T&E process.

B2B practices cover the behavioural (rather than the economic) aspect of the interactions between entities that determine their mutual satisfaction. This thesis has considered the strategic, design and T&E interactions among different parties and how these can enhance the relationship and thus customer satisfaction. A long-term relationship is essential for B2B interactions, which depend mainly on involvement, trust, commitment, perceived quality and thus satisfaction. Interaction requires many elements which are not correctly practised within the AVMs in the Gulf States. These practices may include planned visits, planned customer involvement, planned information exchanges, international exhibition participation, etc.

Finally, although the preceding remarks cover different aspects of customer satisfaction, the author believes they are interrelated and that this interrelationship can be demonstrated by using SE tools such as systems engineering life-cycle processes, the water fall model, the spiral model, the V-process model and, most importantly, the systems engineering life-cycle processes. Moreover, the SSM is a powerful system of thinking that helps the management to discover development process pitfalls together with feasible and desirable solutions to these. The SoS approach, as part of the SE, was utilised in this thesis to demonstrate the dynamic environment situation and the consequences of any change that happens in any one of the constituent SoS members. The SoS entails using the concept of cycle learning to enforce continuous resources enhancement along with time and evolving criteria. This approach resulted in the proposed and approved conceptual framework model with associated enquiries, as shown in Figure 5-8. Moreover, Figure 3-3 indicated the customer satisfaction enablers (involvement, trust, commitment) that lead to the application of the conceptual model for AVM success.

6.4 Recommendations

6.4.1 Recommendations related to NDS

1. The Gulf States, through their related authorities, must seriously consider preparing and publishing respective national defence strategies that determine (1) their long-term objectives, (2) the potential needs of their forces, (3) the type of system required, and (4) their willingness to establish cooperative means with other nations.
2. The NDS must prioritise the local manufacturers to deliver their military needs.
3. The NDS publisher and customer organisations must provide personnel with sufficient operational knowledge to explain their needs and understand any potential threats.
4. The Gulf States may copy the NATO alliance experimentation (which is discussed in chapter 2) if they wish to reinforce their local manufacturers through cooperation with adjacent countries. Moreover, other cases such as Turkey and Norway must be considered as good examples to enhance the defence industry in the Gulf States.
5. The Gulf States are in greater need of reliable industrial networks, which must be a priority for the NDS.
6. The Gulf States can jointly establish the necessary manufacturers to produce physical (subsystems) and intellectual (R&D and T&E) means to support all of the defence industries distributed among them. Such arrangement can certainly optimise the development cost and help to build innovative products.
7. Defence authorities and defence enterprises must work together to plan sufficient economies of scale, thus raising a barrier that prevents foreign entities with similar products gaining a market share. This enables local industries to survive in the market.
8. National civilian authorities, as key national decision influencers, must have sufficient knowledge about defence product development costs, especially the costs of high-tech equipment. This understanding will avoid defence projects being halted or delayed

6.4.2 Recommendations related to business strategy

1. The AVM management must perform comprehensive environmental scanning to gain information about the strengths and weaknesses of the resources, and determine the opportunities and threats that affect AVM performance and customer satisfaction. This will also provide information about the dynamic environment that faces the AVMs and the resources needed to cope with such an environment. Environmental scanning may be held on an annual basis or when significant changes occur within the surrounding environment.
2. A business strategy and mission statement based on the resources and abilities (core competencies) should be prepared to enable the enterprise to achieve the predetermined objectives. Efforts should then be made to maintain this level, thus placing the enterprise in a competitive position. Moreover, the business strategy and mission statement are also important to the AVM stakeholders.
3. It is useful for an AVM to engage with different external stakeholders, especially potential customers, to achieve a learning and innovation process. This type of engagement also allows the AVMs to explore and seize new opportunities.
4. The AVM business strategies will be more effective if they are shared with the stakeholders at specific time intervals.
5. The AVM management must deal with geopolitical issues in a realistic manner and manage their resources based on the current situation.
6. The AVMs need a well-defined sense of their mission, their unique place in their environment, the scope and direction of growth, and a sound management approach.
7. The strategic planning should encompass all employees and stakeholders in a systematic manner.
8. The national defence industry must strive to deploy their products with shorter lead times. Defence product development takes longer than civilian product development. Defence authorities and customers must take this into account.
9. The Defence projects usually involve unexpected numbers of stakeholders, both locally and abroad. Regardless of their influence, one of them may delay or stop the project. Therefore, close collaboration is required to overcome such risks.

6.4.3 Recommendations related to supply chain

1. The AVMs must be aware of the five types of risk, i.e. risks from the environment, demand, supply, process and control. Mitigating risks is one of the key factors that must be considered by AVM management bodies.
2. The AVM management must seek a reliable industrial network that supports their development efforts.
3. The AVM management must select strategies that ensure robust, agile and resilient operations.
4. The industries must be aware of "large fluctuations in demand", especially in response to defence projects. This situation is avoided by diverse production lines, which avoid or at least minimise the depletion of internal resources for a long time.
5. The AVM management must struggle to acquire suitable dynamic resources.
6. Collaboration within the supply chain enhances the relationship and information flow between the three main parties: the developer, subsystem providers, and customers.
7. The management must renew, build-up (incremental) or regenerate their resources.
8. The AVM management must follow strict criteria when selecting subsystem suppliers, especially when these providers are from countries with an uncertain political relationship with the Gulf States.
9. The risk of developing new products is very high when the product involves state-of-the-art technology that must undergo extra testing and evaluation to verify that the level of integration is appropriate. This may involve delays associated with rising costs. Thus, the national industries must focus their competitive capabilities to optimise T&E time and costs.

6.4.4 Recommendations related to design

1. Equipment users should be able to explain their needs to their superiors; when this is impossible, the needs of the equipment users are overlooked.
2. The design team must involve all entities that can add value to the product.
3. The design teams of the Gulf State AVMs must include highly-skilled designers and the latest equipment to ensure that the designs are optimised.

4. The product design phase must include the design of the manufacturing process, as well as the in-process (intermediate) and final T&E.
5. The product design team should visit the customer's premises and join their field exercises in order to determine any latent needs which may be unclear to the customer. Such field visits may also enable the design team to identify any performance gaps that may reveal a need for additional upgrades.

6.4.5 Recommendations related to T&E

1. T&E must be considered as a key part of the development process and should be integrated throughout the development, with pre-defined millstones.
2. T&E must be designed and planned at an early stage of the design process by a team assembled according to the project type. The plan must include the development and operational tests, milestones and phases, who will perform each test, the resources needed for each test, and the test standards, requirements and locations.
3. The AVMs must create the tools needed to establish a T&E schedule efficiently, with clear development milestones throughout the project's life-cycle.
4. The AVMs must offer adequate training to ensure that all individuals have the appropriate knowledge, thus enhancing the competencies of the T&E teams.
5. The AVMs must ensure that enterprises acquire a certain level of professional credibility for T&E purposes. Experts should be unbiased and work with the enterprise and its stakeholders.
6. The AVM management must establish a high-level T&E strategy, with the support of enterprise leaders and management

6.4.6 Recommendations related to interaction

1. The AVM management must plan adequate visits to the customer's premises and the participation of AVM personnel in field operations.
2. There should be greater customer involvement to understand the development cost structure and ensure that the enterprise's price strategy is completely free from exploitation.
3. More customer involvement on the shop floor during production is necessary to ensure that the customer plays a role in the selection of product features (especially hidden features) and trusts the production process to deliver the

product on time. This involvement helps the personnel from each party to interact, which enhances their shared knowledge and relationship.

4. Trust is needed to enhance the interactions between the parties. For example, local AVM owners may display an intention to enhance the ability of their customers to promote the national interests. Moreover, offering technical advice concerning the use of the product may increase the level of trust, whereas unexpected actions by either party will have the opposite effect. Also, the customers should pay more attention to their commitment to the local AVMs, e.g. by promising to fulfil their needs through using local AVMs.
5. Information exchange affects the trust between the parties, but the military side is generally reluctant to supply confidential information until they have obtained permission from a higher authority. The exchange of information requires more attention and planning because some information crucial to the developer might remain concealed even if it is not confidential.
6. The presence of AVMs at international exhibitions will increase customers' confidence and trust in them.
7. The B2B relationships must be exploited to increase the degree of innovation by both parties.

6.5 Research novelty

The thesis aims to enhance the performance of AVMs in the Gulf States using SE tools, which can play two significant roles: (1) ensuring integration among various subsystems (organisational management aspects and product technical aspects) for optimum performance, and (2) revealing current problems and providing desirable and feasible solutions by applying the SoS approach, which deals with the dynamic environment. Because AVMs operating in the Gulf States must deal with sensitive military customers (in terms of costs and timescales), this thesis highlights some issues (gaps) that must be addressed by all relevant parties in the Gulf states: defence authorities, AVMs and customers (particularly end users of the product):

1. The thesis highlights the importance of an NDS, defined as all hierarchal strategies necessary to form a complete paradigm that secures national interests. The thesis related the success of the local AVMs in the Gulf States to the existence of an NDS if the latter specifies the future needs of military

organisations and the strategies that lead to autarky by promoting the support of the national defence industry.

2. The thesis includes a comprehensive integrative literature review that covers all the relevant disciplines and focuses on the values that capture customer satisfaction. The author argues that entrepreneurs should not always rely on intuition, but should adopt systems thinking methods to ensure success and improve value.
3. The thesis demonstrates that the customer satisfaction within B2B relationships relies, to a great extent, on interactions (involvement, commitment and trust) between individuals representing the relevant parties, which is clearly depicted in Figure 3-3. However, interaction with military personnel is different and requires special attention from AVMs. Moreover, the cultural practices in the Gulf States may affect interactions and this should be taken into account by AVM management teams.
4. Finally, the thesis introduces a comprehensive conceptual framework model associated with 13 questions, revealing that:
    a. Enterprises with limited resources, such as SMEs, can use the model easily to review their current position in the dynamic environment and to enhance their performance by answering the 13 questions.
    b. The model highlights the most critical issues that require attention to ensure customer satisfaction.

6.6 Lessons Identified

By the end of this study, the author was convinced that the defence authority is the body responsible for nurturing the national defence industry, which in turn increases the satisfaction of the end-users of AV products. The defence authority can mitigate the risks associated with a dynamic environment, the size of the AVMs, and the prevalent management style (which accepts risks and directs operations in an intuitive manner). Moreover, other lessons can be learnt as an extrapolation of the case study to benefit practitioners and researchers:

1. The importance of the NDS dictates that it should cover all aspects related to the product development process under what is known as “system acquisition management”.

2. Military personnel should receive training on how to articulate their needs as customers.
3. Entrepreneurs must take the NDS into account to enhance their performance in accordance with the military's needs, assuming that the military is their sole customer. Entrepreneurship is essential for innovation. However, in the defence industry, entrepreneurs must focus must more on how to capture customer satisfaction by carefully adopting strategic management concepts.
4. Independent institutes specialised in R&D and T&E are needed to complement the local industrial network.
5. Customer satisfaction rather than product quality must be considered a prime index for enterprise success. The excellent quality of product features does not mean that the customers are happy with the total delivered values. AVM management must understand the elements that contribute to satisfaction in each situation and then strive to fulfil these requirements when the project is executed.
6. Customer involvement must be carefully planned, and the level of interaction should be organised properly, including all levels of management.

6.7 Future research recommendations

Although this thesis focuses on AVMs operating in a dynamic environment, some gaps were discovered as the research progressed, which are listed below:

1. When the conceptual framework model is exposed to changes in the environment, some of its elements may also change. Therefore, different case studies or reference time frames should be tested to identify how these influence the framework.
2. Differences between the defence authorities and civilian manufacturers in terms of culture must be considered and investigated in more detail. In some cases, defence organisations depend exclusively on buying their products from civilian companies. These manufacturers must understand how to deal with military personnel in order to satisfy them
3. The differences between military and private owners (entrepreneurs) should be investigated, in terms of the strategies they use to achieve the goals of the enterprise, military organisations, and the nation, respectively

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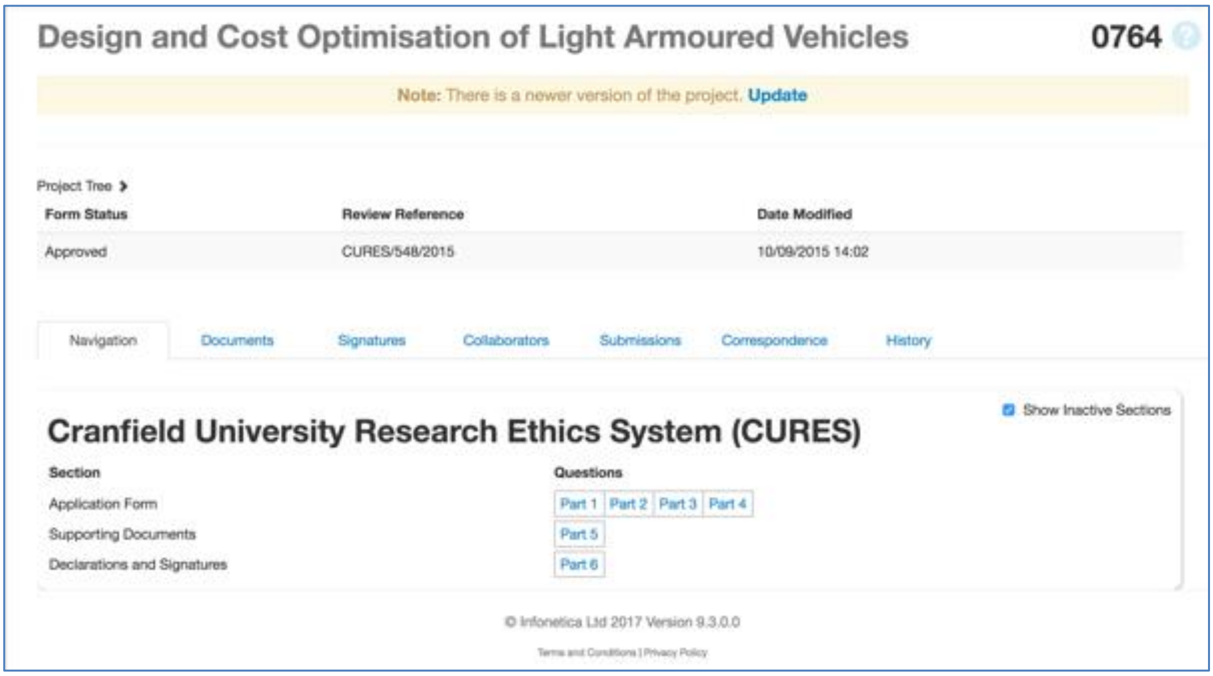
Appendices

Appendix A University Approval (CURES)



Design and Cost Optimisation of Light Armoured Vehicles 0764

Note: There is a newer version of the project. **Update**

Project Tree

Form Status	Review Reference	Date Modified
Approved	CURES/548/2015	10/09/2015 14:02

Navigation | Documents | Signatures | Collaborators | Submissions | Correspondence | History

Show Inactive Sections

Cranfield University Research Ethics System (CURES)

Section	Questions
Application Form	Part 1 Part 2 Part 3 Part 4
Supporting Documents	Part 5
Declarations and Signatures	Part 6

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Appendix B AVMs visit Enquiries.

The following questions were discussed with AVMs managers during the visits:

1. Introduce your enterprise
2. What category does your enterprise belong to? (small, SME, or Large)
3. What external factors do affect your enterprise performance?
4. Do you have a clear employee's selection criteria?
5. Are you willing to acquire quality tools, if you don't have it yet?
6. What type of structure are you dealing with (high span / low span)
7. Do you prefer to have a customising or an on-shelf strategy?
8. To what extent do you imitate your competitors?
9. How do you attract a new customer to buy your products?
10. Do you plan to maintain your communication (relationship) with your customers?
11. How do you know about your customers' needs?
12. Do you have a clear procedures to validate and consolidate your customer needs?
13. To what extant do your customers participate in the design phase?
14. Is it possible for your customer to visit your production-line? Do you have clear roles for customer involvement?
15. Do you prefer that your personals to visit the customer premises and customers' operational fields?
16. Do you have a policy that ensure after-sale follow-up?
17. Do you have clear criteria to select your raw material suppliers?
18. Do you have a clear policy for inspecting subsystems before assembly?
19. Do you prefer to establish a relationship between your customers and your suppliers?
20. Do you encourage your customer to perform intermediate T&E during the production process?

Appendix C **Consent prerequisites**

1. I confirm that I have been informed about the aim and objectives of this research project and agree to give my inputs.
2. I understand that all personal information that is identified from my responses will be treated with the strictest confidence and my name will not be used in any report, publication or presentation.
3. I understand that the information I provide will be used by Cranfield University for the purpose of research only. The data will be stored on a secure network accessed only by authorised users in accordance with the Data Protection Act (1998).
4. I understand that the results of the research may be published in scientific journals, and an anonymised version of the data may be published in support of these results.
5. I understand that I am free to withdraw from this project at any stage prior to the research being published simply by informing the researcher, for whom contact details have been provided. I will need to provide the date and time that I completed the survey.

Appendix D Consent Letter

Dear (customer/manager)

Thank you very much for taking time to assist with this research. I am undertaking this survey as part of a PhD Research. The research is sponsored by Bahraini Defence Force. This being an academic piece of work, at some stage, results will be published in the form of thesis or Journal publication.

The main aim of my research is to evaluate how customer, armoured vehicle manufacturing' companies, and sub-system suppliers need to interact in order for customer to provide critical information concerning their requirements clearly, and manufacturers to translate these requirements into a system which effectively meets customer satisfaction. It is generally believed that customer is not well informed and is not able to define his needs clearly. Poorly defined requirements result in manufacturer proposing systems specifications and implementing numerous changes along the development cycle as customer's understanding improves. Thereby increasing the product cost and unnecessary frustration and loss of trust on both sides. Thus, closer interaction between customer and supplier is important for enhanced satisfaction. Therefore, to begin with, my research initially undertakes a comprehensive review of factors which enhances customer satisfaction. This review has identified certain questions which I need to investigate in order to appreciate how both customer and manufacturer are generally interacting and how/what they should do to improve this interaction which results in better customer satisfaction, reduced cost and timely delivery of product.

To enable me to come up with key factors or activities which would enhance working relationship, satisfaction and mutual trust, I have drafted a set of key questions. Your answers to my questions will confirm the key factors I have identified and will enable me to prioritise their importance relative to defence sector. I would be grateful if you could spend some time answering the questionnaire. To assist you in answering the questionnaire, I would be happy to elaborate any question to help you select the answer which best describes your view.

The questionnaire should take you no more than 20 minutes to answer the questions.
We are not asking for your name but there are requests for information in the survey that might enable us to identify you. However, the data that you provide will be treated in the strictest confidence and you are free to withdraw or change your responses for a period of up to seven days from today. If you need to change anything, then please contact me - email and telephone details below.

Survey data is stored securely by Qualtrics, a US company, based in Ireland (see https://www.qualtrics.com/security-statement/). Core files will be password protected and any information that allows individuals to be identified, such as the name of your institution, will be replaced with pseudonyms. Once the research has been completed, the data will be managed in accordance with Cranfield University's data retention policy and stored within the Research Data Management System for open access purposes, including secondary data analysis.

We would like to follow up this survey with interviews. If you are willing to discuss these issues in more depth, then please leave your contact details in the relevant box at the end of the questionnaire.

Again, thank you for your time and please do make contact if you have any concerns or would like further details.

Col. Eng. Isa Khalifa Aljeeran

Bahrain Defence Force, Kingdom of Bahrain

PhD researcher

Centre for Defence Engineering
Cranfield University at the Defence Academy of the United Kingdom
Shrivenham, SN6 8LA, UK

Appendix E AVMs Questionnaire

Q1. In which country is your firm primarily resident

Q2. What is your position in the company

- Chief Executive/Chairman,
- Senior Executive,
- Manager,
- Technical/Operations
- Support/ Administration,
- Others

Q3. What type of your organisation?

- Local
- Regional
- Multinational
- Others / specify

Q4. To categorise the size of your organisation, how many personnel does your company employ?

- SME
- Large

Q5. What type of ownership best characterizes your company?

- Government (public) ownership
- Part public, part private
- Local private
- International private
- Others/Please specify

Q6 Is there a local defence strategy covering Government Industry relationships in your area?

- Yes
- No
- Not Sure

Q7. To what extent do you agree that Military Industrial strategy defines future equipment needs? (Strongly agree)

Q8. How important are the below listed Strategic Plans to the long-term success of your organization (Extremely important)

a. Your country's National defence strategy (importance scale)
b. Regional defence strategy (importance scale)
c. The Client Country (or supplier country?) defence strategy (importance scale)

Q9. National Defence Strategy requires local customers to buy what they need from domestic manufacturers in my industry sector.

Q10. local industry interacts effectively to form consortia in order to meet government requests to support complex projects.

Q11. Your country's relationships with other countries affect your efforts in gaining regional and international market share.

Q12. It is essential that my organisation has a business strategy that complies with the national defence strategy

Q13. How frequently does your company review its strategy (as it relates to national defence strategy or generally)? Select one (you might include the last option with another)

- Annually
- Every 5 Years
- Every 10 Years
- When there are critical changes in the industry
- Others/Please specify

Q14. It is essential that your organisation's strategy is known to your stakeholders.

Q15 Rank the following four strategies according to your preference in dealing with your customers; (DRAG)

- Cost leadership
- Differentiation
- Focus-cost leadership
- Focus-differentiation (niche)

Q16. How probable is it, that your company could compete in the following markets? (probable-scale)

- Local market
- Regional Market
- Other developing countries market
- Developed countries market

Q17. Your organisation's strategy helped you to prepare your resources (human and capital) to deal with unexpected changes in external environments. (agree-scale)

Q18. How important do you consider the following aspects to the success of your company and its ability to reach its goals.

a. Owner (entrepreneurship practices). (importance scale)
b. Management Skills. (importance scale)
c. Comprehensive design team. (importance scale)
d. Marketing Team. (importance scale)
e. Inspection and evaluation team. (importance scale)
f. The level of technician knowledge. (importance scale)
g. Highly technical machines that operate automatically without human interference. (importance scale)
h. The selection of credible sub-system suppliers. (importance scale)
i. customer interaction. (importance scale)
j. The quality of production process and instruments. (importance scale)

k. After sales. (importance scale)

Q19 Please rank the following actions might take during a high-demand period where production demand exceeds capabilities, rank the following actions (DRAG)

- The company depends on management to deal with unexpected situations.
- The company depends on skilled technicians with adequate authority and knowledge to act quickly.
- The company depends on outsourcing strategy of parts of its production.
- The company depends on relocate technicians along the production line because they are versatile

Q20. To what extent the following tools are important for the management of your organisation (importance-scale)

a. Management by Objective. (importance-scale)
b. ISO systems. (importance-scale)
c. Total Quality Management. (importance-scale)
d. Six-Sigma. (importance-scale)
e. Lean Management. (importance-scale)

Q22. To what extent do you agree that the following testing and evaluation processes add value to the final product? (agree-scale)

a. Intermediate inspection between production phases without the customer. (agree-scale)
b. In-house final test and evaluation without the customer. (agree-scale)
c. In-house final test and evaluation with the customer. (agree-scale)
d. Intermediate inspection between production phases with the customer. (agree-scale)
e. Test and evaluation by the customer alone. (agree-scale)
f. Contracting a third party to test and evaluate the system or subsystem. (agree-scale)

Q22. Hiring ex-military personnel is necessary in order to achieve required levels of performance technically. (Agree-scale)

Q23. To what extent do you agree with the following statement; Having ex-military personnel among your employees is necessary for good communication with your customer organisation. (Agree-scale)

Q24. I prefer to have personnel with the considerable military as well as technical experience as shop-floor managers? (Agree-scale)

Q25. It is important to share product development knowledge with your customers. (Agree-scale)

Q26. To what extent do you believe that the following statements have a significant role in attaining your company goals?

a. The location of a company should be based on the nationality of the owner. (believable-scale)
b. The location of the company should be selected based on government subsidies for power, charges or fees. (believable-scale)

c. The location of the company should be close to the greatest demand for the product. (believable-scale)

Q27. Being in a supply chain network can enhance the performance of any company? (Agree-scale)

Q28 How frequently do you invite your sub-system providers to collaborate in product development.

(Never/Rarely/Occasionally/Sometimes/Frequently/Usually/Every time)

Q29. To what extent do you prefer to deal with the same subsystem supplier for different products? (Preference-scale)

Q30 Investing in and using innovative supply chain methods such as “just in time” is be cost effective for your company (agree-scale)

Q31 Local research institutes are created in order to develop and support specific domestic industries and help them work with the local military organisations. How much have you cooperated with local Research & Development institutes to generate new ideas or innovation? (Frequent-scale)

Q32. To what extent do you agree that developing a solution for your local customers could lead to unique features which differentiate your products from those of your competitors? (agree-scale)

Q33 How important are the following knowledge sharing practices to your ability to meet your customers' overall satisfaction with your products?

a. Your customer shares their technical knowledge with your design team. (importance-scale)
b. Your staffs visit the customer’s premises on a regular basis to investigate their needs in detail. (importance-scale)
c. You occasionally arrange lectures or formal presentations for your customers to educate them on technical issues. (importance-scale)

Q34. The company shares enough information about subsystems with its customers to ensure that spare parts can be made available later and throughout the product life-cycle. (Agree-scale)

Q35. The acquisition process of the buyer's organisation affects the purchase process. For example, the buyer's acquisition procedures may be so long that they unreasonably delay the development process (agree-scale)

Q36. To what extent do you agree with the following statement; Conflicts between the technical and financial individuals in the buyer's organisation frequently delay the purchasing process. (Agree-scale)

Q37. The purchasing process affects the future relationship with your customer? (Agree-scale)

Q38. To what extent do you believe the following factors affect the trust between you and your customers?

a. Price determination methods including cost structure. (agree-scale)
b. Solving the customer's problem. (agree-scale)

c. National similarity. (agree-scale)
d. Continuous customer interactions. (agree-scale)

Q39. It is necessary to join your military customer when the product is used in the field to closely monitor its performance. (agree-scale)

Q40. To what extent do you agree with the following statements regarding customer involvement in the development processes?

a. Customer involvement must be planned and scheduled properly to avoid any delay in the development process. (agree-scale)
b. A customer involvement plan must define individuals who could add considerable value to the development process. (agree-scale)
c. Customer involvement could result in the dissemination of the company's confidential information. (agree-scale)

Q41. Rate to the following practices (out of 10) according to their importance when dealing with your customer in defining their needs and suggesting the solution during the entirety of the product lifecycle

a. The customer suggests a solution and you implement the solution by appropriate design and production (customer-driven innovation). (rate 1-10)
b. Both you and the customer together discuss the customer's needs and suggest a solution (customer-centred innovation). (rate 1-10)
c. The customer makes no contribution and you do everything for the customer (customer-focused innovation). (rate 1-10)

Q42 Rate (out of 10) the following dimensions with regard their effect on the satisfaction of your customer

a. The National Defence Industrial Strategy. (rate 1-10)
b. Your Company Strategy. (rate 1-10)
c. The Research & Development efforts. (rate 1-10)
d. The Design phase contribution (rate 1-10)
e. The quality level of your production tools and process (rate 1-10)
f. The reliability of your logistic system. (rate 1-10)
g. Your test & evaluation arrangements. (rate 1-10)
h. The after-sale services and follow-up. (rate 1-10)
i. Customer Involvement in different of development process. (rate 1-10)
j. Commitment against your customer. (rate 1-10)

Q43. Please take a few seconds to add your valued comments, if any. You are the most expert in your location and nobody else has the level of the knowledge as yours. So, your few words will add tremendous values to my survey.

Appendix F Frequencies

Q1	Frequency	Percent
Non GCC	20	51.3
GCC	19	48.7
Total	39	100.0

Q2- Respondent Positions	Non GCC	GCC	Frequency	Percent
CEO	0	3	3	7.7
senior executive	5	5	10	25.6
managers	12	9	21	53.8
Technical/Operations	1	2	3	7.7
Support/ Administration	2	0	2	5.1
Total	20	19	39	100.0
Q3- AVM geography status	Non GCC	GCC	Frequency	Percent
local	6	7	13	33.3
regional	1	3	4	10.3
multinational	11	8	19	48.7
others	2	1	3	7.7
Total	20	19	39	100.0
Q4- AVM Size	Non GCC	GCC	Frequency	Percent
SME	10	10	20	51.3
Large	10	9	19	48.7
Total	20	19	39	100.0
Q5- Ownership	Non GCC	GCC	Frequency	Percent
Government (public)	3	4	7	17.9
Part public, part private	2	5	7	17.9
Local private	6	2	8	20.5
International private	9	7	16	41.0
Others/Please specify	0	1	1	2.6
Total	20	19	39	100
Q6- Local NDS Availability	Non GCC	GCC	Frequency	Percent
Yes	13	15	28	71.8
No	2	2	4	10.3
Not sure	5	2	7	17.9
Total	20	19	39	100.0

7- Military Industrial strategy defines future equipment							
	1	2	3	4	5	6	7
NGCC	0	0	0	3	4	10	3
GCC	0	0	0	1	8	6	4
Total	0	0	0	4	12	16	7
8A-the importance of the Country's national defence strategy							
	1	2	3	4	5	6	7
NGCC	0	0	0	0	2	9	9
GCC	0	0	1	1	1	7	9
Total	0	0	1	1	3	16	18
8B-Regional defence strategy							
	1	2	3	4	5	6	7
NGCC	0	0	0	0	0	16	4
GCC	0	0	0	0	0	13	6
Total	0	0	0	0	0	29	10
8C-The Client Country (or supplier country) defence strategy							
	1	2	3	4	5	6	7
NGCC	0	0	0	0	2	9	8
GCC	0	0	0	0	5	7	8
Total	0	0	0	0	7	16	16
9- NDS requires local customers to buy what they need from domestic manufacturers							
	1	2	3	4	5	6	7
NGCC	0	0	0	7	2	5	6
GCC	0	0	0	3	5	4	7
Total	0	0	0	10	7	9	13

10- local industry interacts effectively to form consortia							
	1	2	3	4	5	6	7
NGCC	0	0	0	2	4	11	3
GCC	0	0	0	3	4	10	2
Total	0	0	0	5	8	21	5
11- country's relationships with other countries/ gaining market share							
	1	2	3	4	5	6	7
NGCC	0	0	0	3	1	8	8
GCC	0	0	0	2	1	7	9
Total	0	0	0	5	2	15	17
12- It is essential that my organisation has a business strategy							
	1	2	3	4	5	6	7
NGCC	0	0	0	5	1	10	4
GCC	0	0	0	2	1	10	6
Total	0	0	0	7	2	20	10

13- Business Strategy Frequency			
	Annually	5 years	Critical change
NGCC	8	2	9
GCC	9	2	7
Total	17	4	16

14 - Strategy Known to stakeholder							
	1	2	3	4	5	6	7
NGCC	0	0	0	2	5	10	3
GCC	0	0	0	4	2	7	6
Total	0	0	0	6	7	17	9
16 A- compete Local market							
	1	2	3	4	5	6	7
NGCC	0	0	0	4	4	0	12
GCC	0	0	0	3	1	0	15
Total	0	0	0	7	5	0	17
16B- compete regional market							
	1	2	3	4	5	6	7
NGCC	0	0	0	2	8	0	10
GCC	0	0	0	3	8	0	8
Total	0	0	0	5	16	0	18
16C- Compete in developing countries							
	1	2	3	4	5	6	7
NGCC	0	0	0	5	9	0	6
GCC	0	0	0	4	8	0	7
Total	0	0	0	9	17	0	13
16D- Compete in developed countries							
	1	2	3	4	5	6	7
NGCC	0	0	0	6	9	0	5
GCC	0	0	0	11	2	0	6
Total	0	0	0	17	11	0	11
17- strategy helped you to prepare your resources							
	1	2	3	4	5	6	7
NGCC	0	0	0	6	3	7	4
GCC	0	0	0	0	5	11	3
Total	0	0	0	6	8	18	7
18A-entrepreneurship practices							
	1	2	3	4	5	6	7
NGCC	0	0	0	0	5	9	6
GCC	0	0	0	0	4	9	6
Total	0	0	0	0	9	18	12
18B- Management Skills							
	1	2	3	4	5	6	7
NGCC	0	0	0	0	2	8	10
GCC	0	0	0	0	0	7	12
Total	0	0	0	0	2	15	22
18C- Comprehensive design team							
	1	2	3	4	5	6	7
NGCC	0	0	0	0	2	8	10
GCC	0	0	0	0	4	5	10
Total	0	0	0	0	6	13	20

18D- Marketing team							
	1	2	3	4	5	6	7
NGCC	0	0	0	0	4	9	7
GCC	0	0	0	0	3	8	8
Total	0	0	0	0	7	17	15
18E- Inspection and evaluation team							
	1	2	3	4	5	6	7
NGCC	0	0	0	0	3	14	3
GCC	0	0	0	0	2	6	11
Total	0	0	0	0	5	20	14
18F-The level of technician knowledge							
	1	2	3	4	5	6	7
NGCC	0	0	0	0	2	10	8
GCC	0	0	0	0	1	8	10
Total	0	0	0	0	3	18	18
18G- Highly technical machines							
	1	2	3	4	5	6	7
NGCC	0	2	0	3	6	5	4
GCC	0	0	3	5	6	3	2
Total	0	2	3	8	12	8	6
18H- selection of credible sub-system suppliers							
	1	2	3	4	5	6	7
NGCC	0	0	0	0	4	9	7
GCC	0	0	0	0	3	8	8
Total	0	0	0	0	7	17	15
18 I- customer interaction							
	1	2	3	4	5	6	7
NGCC	0	0	0	0	3	14	3
GCC	0	0	0	0	2	6	11
Total	0	0	0	0	5	20	14
18J- quality of production process and instruments							
	1	2	3	4	5	6	7
NGCC	0	0	0	0	2	10	8
GCC	0	0	0	0	1	8	10
Total	0	0	0	0	3	18	18
18 K- after-sales services							
	1	2	3	4	5	6	7
NGCC	0	2	0	3	6	5	4
GCC	0	0	3	5	6	3	2
Total	0	2	3	8	12	8	6
20B- ISO system							
	1	2	3	4	5	6	7
NGCC	0	0	1	2	2	9	6
GCC	0	0	1	1	6	6	5
Total	0	0	2	3	8	15	11
20C-TQM							
	1	2	3	4	5	6	7
NGCC	0	0	4	3	2	10	1
GCC	0	0	1	2	7	5	4
Total	0	0	5	5	9	15	5
20D- Six sigma							
	1	2	3	4	5	6	7
NGCC	0	2	0	3	6	5	4
GCC	0	0	3	5	6	3	2
Total	0	2	3	8	12	8	6
20E-Lean Management							
	1	2	3	4	5	6	7
NGCC	0	0	3	0	2	13	2
GCC	0	0	1	1	4	7	6
Total	0	0	4	1	6	20	8
21A-Intermediate inspection without customer							
	1	2	3	4	5	6	7
NGCC	0	0	2	1	1	11	5
GCC	0	0	3	0	1	9	6
Total	0	0	5	1	2	20	11

21B-In-house final test w/o customer							
	1	2	3	4	5	6	7
NGCC	0	0	1	1	3	6	9
GCC	0	0	2	1	1	5	10
Total	0	0	3	2	4	11	19
21C-In-house final test with customer							
	1	2	3	4	5	6	7
NGCC	0	0	0	0	1	8	11
GCC	0	0	0	0	2	7	10
Total	0	0	0	0	3	15	21
21D-Intermediate inspection w customer							
	1	2	3	4	5	6	7
NGCC	0	1	2	1	2	10	4
GCC	0	3	0	4	3	5	4
Total	0	4	2	5	5	15	8
21E- Test and evaluation by the customer							
	1	2	3	4	5	6	7
NGCC	0	2	1	3	5	8	1
GCC	0	2	5	3	3	3	3
Total	0	4	6	6	8	11	4
21F third party to test and evaluate							
	1	2	3	4	5	6	7
NGCC	2	2	2	2	6	4	4
GCC	0	2	0	3	5	6	3
Total	0	4	2	5	11	10	7
22- Hiring ex-military personnel is necessary							
	1	2	3	4	5	6	7
NGCC	0	1	2	5	4	6	2
GCC	0	2	2	3	8	4	0
Total	0	3	4	8	12	10	2
23- ex-military personnel is necessary for good communication with customer organisation							
	1	2	3	4	5	6	7
NGCC	0	2	1	2	7	4	4
GCC	0	2	1	1	3	9	3
Total	0	4	2	3	10	13	7
24- shop-floor managers with the considerable military/technical experience as							
	1	2	3	4	5	6	7
NGCC	0	0	3	4	5	6	2
GCC	0	0	5	6	2	4	2
Total	0	0	8	10	7	10	4
25- Sharing product development knowledge with your customers							
	1	2	3	4	5	6	7
NGCC	0	0	2	1	2	6	9
GCC	0	0	1	3	4	5	6
Total	0	0	3	4	6	11	15
26A- location of a company							
	1	2	3	4	5	6	7
NGCC	8	0	1	7	1	2	1
GCC	5	1	1	4	3	4	1
Total	13	1	2	11	4	6	2
26B- The location should be selected based on government subsidies for power, charges or fees							
	1	2	3	4	5	6	7
NGCC	4	1	1	3	5	3	3
GCC	1	3	1	2	3	7	2
Total	5	4	2	5	8	10	5
26C- location of the company should be close to the greatest demand							
	1	2	3	4	5	6	7
NGCC	0	1	2	4	5	7	1
GCC	0	2	0	1	1	4	11
Total	0	3	2	5	6	11	12
27- supply chain network enhances the performance of any enterprise							
	1	2	3	4	5	6	7
NGCC	0	0	0	0	4	8	8
GCC	0	0	0	2	2	12	3
Total	0	0	0	2	6	20	11

28- frequency of inviting sub-system providers to collaborate in product development							
	1	2	3	4	5	6	7
NGCC	0	3	5	3	8	1	0
GCC	0	5	3	2	6	2	1
Total	0	8	8	5	14	3	1
29- dealing with the same subsystem supplier for different products							
	1	2	3	4	5	6	7
NGCC	0	0	3	0	3	12	2
GCC	0	5	1	0	3	8	2
Total	0	5	4	0	6	20	4
30- Using of just in time is cost effective							
	1	2	3	4	5	6	7
NGCC	0	0	2	3	2	11	2
GCC	0	3	2	2	1	8	3
Total	0	3	4	5	3	19	5
31- Cooperating with local Research & Development							
	1	2	3	4	5	6	7
NGCC	4	0	1	0	6	0	9
GCC	8	0	7	0	2	0	2
Total	12	0	8	0	8	0	11
32- developing a solution for local customers lead to unique features comparing to competitors							
	1	2	3	4	5	6	7
NGCC	0	0	0	2	1	11	6
GCC	0	0	0	2	5	6	6
Total	0	0	0	4	6	17	12
33A- customer shares their technical knowledge enhances customer satisfaction							
	1	2	3	4	5	6	7
NGCC	0	0	0	4	5	10	1
GCC	0	0	0	1	5	8	5
Total	0	0	0	5	10	18	6
33B- visiting customer’s premises enhances customer satisfaction							
NGCC	0	0	0	0	4	10	6
GCC	0	0	0	0	4	7	8
Total	0	0	0	0	8	17	14
33C- arranging lectures for customer enhances customer satisfaction							
	1	2	3	4	5	6	7
NGCC	0	0	1	0	6	7	6
GCC	0	0	2	2	5	4	6
Total	0	0	3	2	11	11	12
34- sharing knowledge with customer with regards spare parts for latter better support							
	1	2	3	4	5	6	7
NGCC	0	0	0	1	6	10	3
GCC	0	0	2	0	3	7	7
Total	0	0	2	1	9	17	10
35- The effect of customer -acquisition process on the product development process							
	1	2	3	4	5	6	7
NGCC	0	0	0	2	2	7	9
GCC	0	0	0	2	2	10	5
Total	0	0	0	4	4	17	14
36- Conflicts between the technical and financial individuals in the buyer's organisation frequently delay the purchasing process							
	1	2	3	4	5	6	7
NGCC	0	0	2	0	3	7	8
GCC	0	0	2	3	5	3	6
Total	0	0	4	3	8	10	14
37- purchasing process affects the future relationship with your customer							
	1	2	3	4	5	6	7
NGCC	0	0	1	0	6	9	4
GCC	0	0	3	3	3	5	5
Total	0	0	4	3	9	14	9
38A- Price determination methods including cost structure affect the trust between parties							
	1	2	3	4	5	6	7
NGCC	0	0	4	0	3	10	3
GCC	0	0	1	2	7	6	3
Total	0	0	5	2	10	16	6
38B- Solving the customer's problem affect the trust between parties							
	1	2	3	4	5	6	7
NGCC	0	0	0	0	0	7	13
GCC	0	0	0	0	0	8	11
Total	0	0	0	0	0	15	24

38C- National similarity affect the trust between parties							
	1	2	3	4	5	6	7
NGCC	0	3	3	5	6	3	0
GCC	0	2	1	6	6	2	2
Total	0	5	4	11	12	5	2
38D- Continuous customer interactions affect the trust between parties							
	1	2	3	4	5	6	7
NGCC	0	0	0	0	1	8	11
GCC	0	0	0	0	3	7	9
Total	0	0	0	0	4	15	20
39- Joining customer operational field monitor closely the product performance							
	1	2	3	4	5	6	7
NGCC	0	0	0	1	7	6	6
GCC	0	0	0	1	4	7	7
Total	0	0	0	2	11	13	13
40A- Customer involvement must be planned to avoid development delay							
	1	2	3	4	5	6	7
NGCC	0	0	0	2	2	11	5
GCC	0	0	0	1	3	7	8
Total	0	0	0	3	5	18	13
40B- customer involvement must define individuals who can add value to development process							
	1	2	3	4	5	6	7
NGCC	0	0	0	2	5	10	3
GCC	0	0	0	4	4	5	6
Total	0	0	0	6	9	15	9
40C- Customer involvement can harm the developer confidential information							
	1	2	3	4	5	6	7
NGCC	0	0	4	4	5	6	1
GCC	0	0	6	1	10	1	1
Total	0	0	10	5	15	7	2

Appendix G : Mann-Whitney

Q		Location	N	Mean Rank	Sum of Ranks
7	Military Industrial strategy defines future equipment needs	NGCC	20	20.13	402.50
		GCC	19	19.87	377.50
8A	The importance of the country's National defence strategy to the long-term success of the enterprise?	NGCC	20	20.20	404.00
		GCC	19	19.79	376.00
8B	The importance of the regional defence strategy to the long-term success of the enterprise?	NGCC	20	18.90	378.00
		GCC	19	21.16	402.00
8C	The importance of the client country (or supplier country?) defence strategy to the long-term success of the enterprise?	NGCC	20	19.03	380.50
		GCC	19	21.03	399.50
9	NDS requires local customers to buy what they need from domestic manufacturers	NGCC	20	18.73	374.50
		GCC	19	21.34	405.50
10	Local industry interacts effectively to form consortia to meet government requests to support complex projects.	NGCC	20	20.95	419.00
		GCC	19	19.00	361.00
11	Country's relationships with other countries affect your efforts in gaining regional and international market share.	NGCC	20	19.18	383.50
		GCC	19	20.87	396.50
12	It is essential that my organisation has a business strategy that complies with the national defence strategy	NGCC	20	18.08	361.50
		GCC	19	22.03	418.50
14	Organizational Strategy is known to stakeholders	NGCC	20	19.10	382.00
		GCC	19	20.95	398.00
16 A	Compete in Local market	NGCC	20	18.40	368.00
		GCC	19	21.68	412.00
16 B	Compete in regional market	NGCC	20	20.95	419.00
		GCC	19	19.00	361.00
16 C	Compete in developing countries	NGCC	20	19.25	385.00
		GCC	19	20.79	395.00
16 D	Compete in developed countries	NGCC	20	21.55	431.00
		GCC	19	18.37	349.00
17	Business strategy help management better to prepare their resources	NGCC	20	18.05	361.00
		GCC	19	22.05	419.00
Q 18	The extent that the following aspects contribute to the success of your company and its ability to reach its goals				
A	Owner (entrepreneurship practices) (1)	NGCC	20	19.63	392.5
		GCC	19	20.39	387.5
B	Management Skills (2)	NGCC	20	18.4	368
		GCC	19	21.68	412
C	Comprehensive design team (3)	NGCC	20	20.3	406
		GCC	19	19.68	374
D	Marketing Team (4)	NGCC	20	19.2	384
		GCC	19	20.84	396
E	Inspection and evaluation team (5)	NGCC	20	16.18	323.5
		GCC	19	24.03	456.5
F	The level of technician knowledge (6)	NGCC	20	18.65	373
		GCC	19	21.42	407
G	Highly technical machines that operate automatically without human interference (7)	NGCC	20	22.1	442
		GCC	19	17.79	338
H	The selection of credible sub-system suppliers (8)	NGCC	20	19.2	384
		GCC	19	20.84	396

J	customer interaction (9)	NGCC	20	16.18	323.5
		GCC	19	24.03	456.5
K	The quality of production process and instruments	NGCC	20	18.65	373
		GCC	19	21.42	407
Q 20	To what extent the following tools are important for the management of your organisation				
A	Management by Objective (MOB) (1)	NGCC	20	20.7	414
		GCC	19	19.26	366
B	ISO system (2)	NGCC	20	21.08	421.5
		GCC	19	18.87	358.5
C	Total Quality Management TQM (3)	NGCC	20	17.8	356
		GCC	19	22.32	424
D	Six Sigma (4)	NGCC	20	18.65	373
		GCC	19	21.42	407
E	Lean Management (5)	NGCC	20	18.75	375
		GCC	19	21.32	405
Q 21	To what extent do you agree that the following testing and evaluation processes add value to the final product?				
A	Intermediate inspection between production phases without the customer	NGCC	20	19.65	393
		GCC	19	20.37	387
B	In-house final test and evaluation without the customer	NGCC	20	19.45	389
		GCC	19	20.58	391
C	In-house final test and evaluation with the customer	NGCC	20	20.45	409
		GCC	19	19.53	371
D	Intermediate inspection between production phases with the customer	NGCC	20	21.63	432.5
		GCC	19	18.29	347.5
E	Test and evaluation by the customer alone	NGCC	20	21.65	433
		GCC	19	18.26	347
F	Contracting a third party to test and evaluate the system or subsystem.	NGCC	20	19.5	390
		GCC	19	20.53	390
22	Hiring ex-military personnel is necessary in order to achieve required levels of performance technically	NGCC	20	21.43	428.5
		GCC	19	18.5	351.5
23	Having ex-military personnel among your employees is necessary for good communication with your customer organisation	NGCC	20	18.8	376
		GCC	19	21.26	404
24	I prefer to have personnel with the considerable military as well as technical experience as shop-floor managers	NGCC	20	21.78	435.5
		GCC	19	18.13	344.5
25	Intermediate It is important to share product development knowledge with your customers	NGCC	20	21.63	432.5
		GCC	19	18.29	347.5
Q 26	To what extent do you believe that the following statements have a significant role in attaining your company goals	Location	N	Mean Rank	Sum of Ranks
A	Intermediate inspection between production phases without the customer	NGCC	20	18.13	362.5
		GCC	19	21.97	417.5
B	In-house final test and evaluation without the customer	NGCC	20	18.7	374
		GCC	19	21.37	406
C	In-house final test and evaluation with the customer	NGCC	20	14.9	298
		GCC	19	25.37	482
27	Being in a supply chain network can enhance the performance of any company	NGCC	20	22.1	442
		GCC	19	17.79	338
28	How frequently do you invite your sub-system providers to collaborate in product development	NGCC	20	19.9	398
		GCC	19	20.11	382

29	To what extent do you prefer to deal with the same subsystem supplier for different products	NGCC	20	22.05	441
		GCC	19	17.84	339
30	Investing in and using innovative supply chain methods such as “just in time” is be cost effective for your company	NGCC	20	20.9	418
		GCC	19	19.05	362
31	How much have you cooperated with local Research & Development institutes to generate new ideas or innovation	NGCC	20	24.78	495.5
		GCC	19	14.97	284.5
32	developing a solution for your local customers could lead to unique features which differentiate your products from those of your competitors	NGCC	20	21.13	422.5
		GCC	19	18.82	357.5
Q 33	How important are the following knowledge sharing practices to your ability to meet your customers' overall satisfaction with your products	Location	N	Mean Rank	Sum of Ranks
A	Your customer shares their technical knowledge with your design team	NGCC	20	17.3	346
		GCC	19	22.84	434
B	Your staff visit the customer’s premises on a regular basis to investigate their needs in detail	NGCC	20	19.15	383
		GCC	19	20.89	397
C	You occasionally arrange lectures or formal presentations for your customers to educate them on technical issues	NGCC	20	21.15	423
		GCC	19	18.79	357
34	The company shares enough information about subsystems with its customers to ensure that spare parts can be made available later and throughout the product life-cycle	NGCC	20	18.23	364.5
		GCC	19	21.87	415.5
35	The acquisition process of the buyer's organisation affects the purchase process	NGCC	20	21.48	429.5
		GCC	19	18.45	350.5
36	Conflicts between the technical and financial individuals in the buyer's organisation frequently delay the purchasing process	NGCC	20	22.15	443
		GCC	19	17.74	337
37	The purchasing process affects the future relationship with your customer	NGCC	20	21.3	426
		GCC	19	18.63	354
Q 38	Factors affect the trust between you and your customers?	Location	N	Mean Rank	Sum of Ranks
A	Price determination methods including cost structure	NGCC	20	20.7	414
		GCC	19	19.26	366
B	Solving the customer's problem	NGCC	20	20.68	413.5
		GCC	19	19.29	366.5
C	National similarity	NGCC	20	18.53	370.5
		GCC	19	21.55	409.5
D	Continuous customer interactions	NGCC	20	21.15	423
		GCC	19	18.79	357
39	It is necessary to join your military customer when the product is used in the field to closely monitor its performance	NGCC	20	18.78	375.5
		GCC	19	21.29	404.5
Q 41	To what extent do you agree with the following statements regarding customer involvement in the development processes				
A	Customer involvement must be planned and scheduled properly to avoid any delay in the development process	NGCC	20	18.68	373.5
		GCC	19	21.39	406.5
B	A customer involvement plan must define individuals who could add considerable value to the development process?	NGCC	20	19.85	397
		GCC	19	20.16	383
C	Customer involvement could result in the dissemination of the company's confidential information	NGCC	20	21.58	431.5
		GCC	19	18.34	348.5

Appendix H Environment Assessment: SWOT Analysis

Strengths	• AVMs are owned and managed by entrepreneurs who adopt innovation and new ideas quickly • Entrepreneurs communicate better with their stakeholders • The AVM shop-floor is managed by one manager who is very qualified in management and technical aspects. • Easier communication and coordination among employees / high motivation due to easy communication • Simple and less bureaucratic decision-making process • AVMs usually hire qualified welders to deal with armoured material • AVMs, in some cases, hire ex-military individual to manage the shop-floor or as a consultant. • Less management layers reduces cost.
Weaknesses	• Entrepreneurs accept risks and manage intuitively. • Most of the technicians are fitters with low-skills. • High turn-over with less of learning cycle/ usually there is no training plan • Technicians are from different countries and languages making communication difficult. • Lack of employee responsibility allocation • Less motivation due to lack of promotions. • Design team is not comprehensive with inadequate resources (human and instrument) • Design/Production/T&E are not well defined • Lack of quality criteria and dimension • Lack of customer/subsystem providers involvement plan
Opportunities	• The facilities offered by the host country that reduce the expenses and consequently lower the cost of end-products. • The high demand for armoured products from surrounding countries. • UAE and Saudi Arabia reinforce other countries' security forces by donating AVs manufactured by local AVMs. These military aids would increase the demand for armoured vehicles. • Direct and easy contact between the local AVMs and the local military authorities provide insight to their needs and introduces possible values and solutions. However, some of this information is yet not formal. • The strategic location of the Gulf States helps to access the raw material resources from around the world and customers as well. • Gulf States offer cheap electrical energy and no taxes. This would affect the operational costs. • Emergent of customer needs may occur anytime due to emergent threats in the area.
Threats	• The entrepreneurship management style accepts risks that might harm their enterprises anytime. • The political conflict between the Gulf States and the country exporting the raw material may ban the subsystem parts from reaching the manufacturer. • The fierce competition from some countries like Turkey. Turkish manufacturers produce almost everything and can offer their products at competitive prices. • All human resources including management are foreigners. This might affect the AVMs operations during any crises. • Some developing countries such as the USA and the UK interfere with the supply of some items mounted on the armoured vehicles for some countries (end-user license) which affects the sale of the entire product. • The evolving in technology in the armour field may reach AVMs in the Gulf States after their competitors in the developed countries.

Appendix I Environmental Assessment: PESTEL analysis.

Political	• The increase of domestic terrorist acts which increases the arm needs • Enhancing the relationship with countries widen the market for local manufacturers and network • Dramatic changes in external policy in both Gulf States toward the developing countries (or vice versa) which might harm the future arms supply, including spare parts for existing systems • The needs to governmental legislations such as the NDS to enforce the local industry • The geographic location of the Gulf States allows them to deal moderately with other countries
Economic	• The economic environment of the Gulf States is strong and promising • Considerable amount of the Gulf States budget is devoted to defence and more specifically equipment procurement • The Gulf States are willing to construct different industries by encouraging foreigner enterprises to operate from their territories and local investors to establish their business. • The Gulf States support SMEs as an excellent way to prosper the local industry • The competition in armoured industry is internationally very fierce. • Gulf countries have no tax on the industry which encourages business to incest • The inflation in the Gulf States is constant • The Gulf States strive to increase their exports through different industries including the defence industry. • The high number of wealthy individual leads to increase the opportunity to invest on armoured industry , increase the number of AVMs and thus increase competitions • Free-zone help enterprises in their business
Social	• The interaction between AVMs and their local customers influenced by cultural norms in the Gulf States • The relationship between individual from AVM and customer organisation controlled to a high extant by ethical values. • The social unity in the Gulf States play a significant role in deciding the relationship among different parties. • Trust is very important element in the relationship among various parties in the Gulf States. • Involvement is needed to enforce the relationship between the customer and AVMs' individuals. • The Gulf States customers may like the informal relationship which evolved to be formal in future • Military organisation may interact with the developer anytime • The relationship among AVM employee is not strong due to (1) foreigner worker and (2) high turnover. • Reliable network that control the relationship among various parties is required.
Technology	• The tremendous armoured technologies available to the manufacturers lead to the acquisition of better products at relatively lower costs. • Different subsystem suppliers are working harder to invent new technology (higher quality at lower costs) to make available to different manufacturers for different purposes and uses/ selecting criteria is necessary • New process technology is available for AVMs to enhance their productivity / • Quality standards are important to evaluate productivity. • Partnership with manufacturers from developing countries is essential to bring the state-of-art technology to local AVM • R&D institutes are essential however they are not existing in the Gulf States • Communication and information flow is very simple in the Gulf States due to high-tech infrastructure. • Training must be conducted alongside with technology advancement.
Environment	• Some issues that must be considered during design and T&E: high temperature and issues Intensive dust
Legal	• No published NDS is available • Local military organisation must establish and publish an NDS to control the local industry and achieve autarky. • Gulf States Government may establish institutes that serve R&D and T&E.