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SESAR: GETTING GOOD VALUE FOR AIRLINES

Peter Brooker

Cranfield University

'Even the longest journey must begin where you stand.'   Lao-tzu

'In the long run, we're all dead.'   J. M. Keynes

Abstract

SESAR is Europe's 'Single European Sky Air traffic Research system', targeted at post 2020. The vision is to integrate and implement new technologies to improve air traffic management (ATM) performance. The focus for planning and executing system operations will increasingly be aircraft navigating high-quality 4D trajectories: a 4D trajectory is the aircraft path, three space dimensions plus time, from gate-to-gate, ie including the path along the ground at the airport. A 20+ year ATM plan has to use limited information on the success of innovations and the development of large-scale, often safety critical, software (which by its nature can take markedly longer and costs markedly more than early estimates). SESAR must be sufficiently flexible in deployment to maximise financial benefits to individual stakeholders *using their specific financial criteria*. Airline needs are the main ATM system/business drivers. Airlines do not want to commit to developing an 'ultra-modern system' *per se*, but rather to one that makes business-sensible investments in new technologies that are indispensable for achieving improved safety and meeting projected capacity requirements. The approach is been to use simple corporate finance ideas to examine the different viewpoints and business environments of air traffic service suppliers ('ANSPs') and individual airlines. The key decision-making point is that ANSPs act as agents for airlines as a whole. The key financial point is that a typical airline has to work hard to survive and needs quick paybacks on investment. The design of the SESAR R&D and project portfolios can learn lessons from information technology systems design and deployment. 'Real option analysis' of systems can increase business value by improving the sequencing and partitioning of projects, helping to ensure that the system is adaptable to technological innovation and changes in business needs.

1. Introduction

The quotations above are a good summary of the following pages. ATM – Air Traffic Management – R&D, strategies and plans have to start from the present system. The 'long run' is not always the right time framework for decisions. Airlines do not live as long as people do.

SESAR is the Single European Sky Air traffic Research system (Brooker, 2008). A SESAR-era ATM system would ensure flights are on time and navigate 4D (four-dimensional) fuel-efficient flightpaths. Several practical questions arise:

How long will it take to create it?

How much capacity has to be planned for?

What technical/operational choices are there?

Mix of COTS (Commercial Off-the-Shelf) technology and R&D?

What are wise airline investments?

Is SESAR solving the right problems?

The issues are about making financially orientated decisions in the context of a technology and business environment. Safety is the paramount concern – the analysis here is about safe ATM futures.

2. SESAR

Why are the words SESAR, Airlines and Value in the title?
Bullet point answers are:

SESAR?

- Europe's 'Single European Sky Air traffic Research system'
- Targeted at post 2020
- Integrate new technologies to improve ATM performance

Airlines?

- Core of system design is to meet airline/passenger needs
- Direct costs and contributions to air traffic control (ATC) route charges
- Society/GDP gains
- But huge implications for military, general/business aviation

Value?

- Airlines operating in a challenging commercial market
- Progress with SESAR will only happen if *all* the key stakeholders agree to invest money in its core projects

The key point is that changes to the design of the ATM system have to meet commercial aviation's needs. However, it must be reiterated that there are massive implications for military and business aviation (SDG, 2005).

A set of bullet points about SESAR is (SESAR Consortium, 2007).

Gate-to-gate system integration

Change from *reactive ATM* to *anticipatory ATM*

Co-operative:

- 4D Trajectory planning & support tools
- New roles & task distribution for pilots & controllers
- Airborne separation assistance
- Collaborative decision-making (ATM/Airlines/Airport)

Network of ground-to-air data links to enable accurate 'trajectory' information exchanges

System-Wide Information Management & Interoperability

Exploit satellite navigation/communications technology

The components of SESAR seem very reasonable ones – many have a long history. Twenty years ago, the bottom two would not be there – intranet-type systems as a backbone for everything, and satellite positioning. SESAR's 'hard cash' financial benefits are aimed at removing barriers to peak-hour flights, reduced flight delays, ATM costs, and fuel usage. Aircraft would navigate more direct, better flight-profile, more fuel-efficient routes.

3. Airline Industry Issues

What issues does the airline industry face? The yearly figures in Figure 1 show how bad the recent crude oil price shock has been. People now hope oil prices reached the peak, and the price will adjust down to <$100 a barrel over the long term. Jet kerosene costs are now a much larger part of operating costs than in 2001.

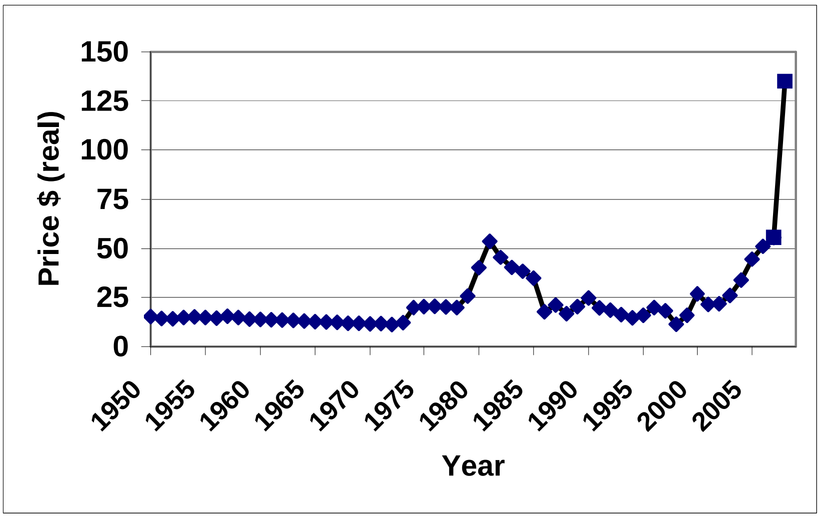

Figure 1. Crude Oil Price History – and Shocks (2007$: EIA, 2008 plus notional $135/barrel for 2008)

People now hope oil prices reached the peak, and the price will adjust down to much less than $100 a barrel over the long term. Jet kerosene costs are now a much larger part of operating costs than in 2001.

Airlines had a good chance of failing *before* the credit crunch and the oil/jet kerosene price shocks. The median lifetime of defunct UK airlines to mid-2008, before the recent spate of airline problems, was about nine years – Figure 2. A major cash flow problem, not being able to pay bills, is the 'heart failure' of a business.

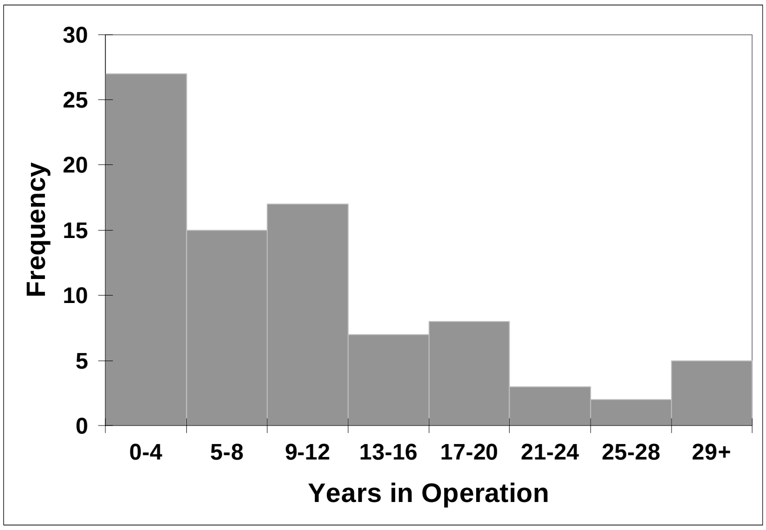

Figure 2. Defunct Post-war UK Airlines (Mid-year 2008 data)

Airlines as a whole do not consistently make profits. The fitted graph in Figure 3 derives from an MIT paper by Jiang and Hansman (2006). It is a sinusoidal curve, with an ~11-year cycle, overlaid on exponential growth. An unstable growth path usually indicates problems with system lags – in capacity response and cost adjustment. The projected twenty billion dollar plus profits for 2008 now exist only in the airlines' dreams.

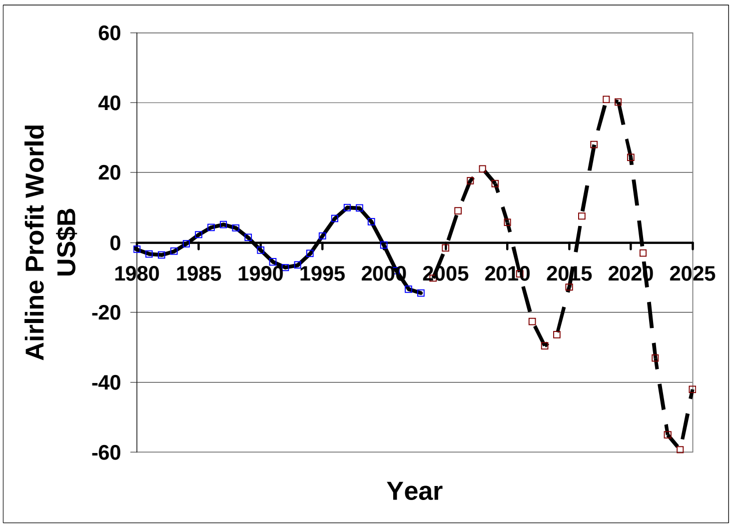

Figure 3. Projected (2004) World Airline Profitability

4. Corporate Finance Approach to ATM/SESAR

SESAR's objectives appear technically feasible, but there are big questions about how to achieve these through optimally-chosen technical investment paths. Almost all of the technologies encompassed in SESAR have long histories of successful research. The key issues are about *which* R&D & implementation projects should decision-makers chose? Which system functions need replacement, overlaid subsystems or be entirely new?

The approach here is to use some simple corporate finance ideas:

Examine different viewpoints & business environments of ANSPs & individual airlines.

Focus on airspace capacity.

Focus on succession of R&D & projects.

The focus here is on how R&D and implementation projects make business sense. Businesses make choices based on the information available to them about costs and benefits, in the context of general strategies.

ANSPs – Air Navigation Service Providers, such as UK NATS – provide today's ATC services but they also invest in new kit to meet tomorrow's needs. They are essentially acting as *'ATM agents'* for the airlines in procuring the necessary ground ATM systems. ANSPs need to convince airline customers that capital expenditure plans are *necessary* to meet future traffic growth cost-effectively. Capital investments do not automatically reduce unit costs to customers: the rationale for an investment is that it is a better bargain for the future than other options.

ANSPs are not there to make big profits for the state or their owners. ANSPs are not normal commercial (economically unregulated) companies. This would lead to investment problems – one reason why the government set up NATS as a Public-Private Partnership.

5. Corporate Finance Tools for CBA

Table 1 lists some appropriate corporate finance tools for cost benefit analysis – CBA – in the widest sense (eg see Brealey et al, 2007).

NPV	$\sum (B_i – D_i – C_i) / (1 + r)^i$
Terminal Value	NPV post the planning period – assumes simple growth in net benefits
Real Option Valuation	A 'real option' embodies flexibility in the development of a project – a form of insurance or means to take advantage of a favourable situation 'Real options analysis' is body of techniques used to value flexibility in the deployment of technical systems, Information Technology (IT) infrastructure (computer reservation systems)

Table 1. Investment Decisions: Corporate Finance Tools

NPV is the standard, B, D and C are benefits, disbenefits and costs – r is the rate of return, often called the investment hurdle rate. The terminal value looks beyond the planning period and extrapolates the growth in annual net benefits. Real option valuation is incredibly complicated. A key theme is valuing flexibility in system deployment. Infrastructures with high potential for a variety of future strategic options can be designed to have very high investment values (Tallon et al, 2002; Fichman, 2004; Steffens and Douglas, 2007; de Neufville et al, 2008).

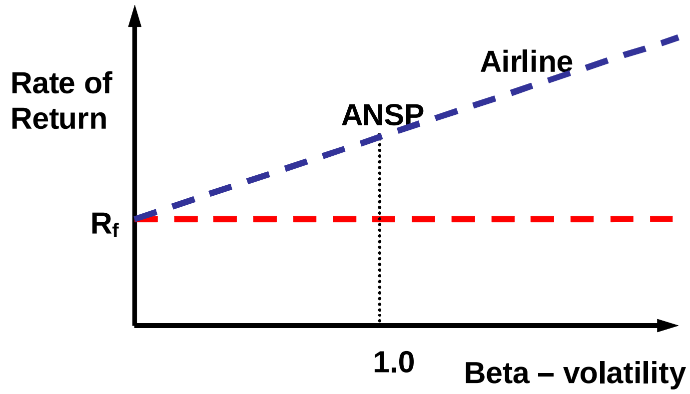

Figure 4. Capital Asset Pricing Model
NB: SESAR NPVs do not generally use different rates

Figure 4 is the famous graph from corporate finance textbooks (eg see Brealey et al, 2007). It shows the rate of return required on investments versus Beta. Beta measures the volatility in a firm's return on shares associated with general movements in the stock market and the economy. R_f is the risk free rate. High Beta – > 1 – is a higher risk stock. Low Beta – < 1 – is a lower risk stock. Airlines have effective Betas > 1, ANSPs ~1. This simply means that airlines require much higher rates of return on investments than ANSPs (PwC, 2004; Turner and Morrell, 2003).

6. ATM, SESAR and Projects

This crucial financial logic for ATM and SESAR is set out in Figure 5. The aim is to generate an 'optimum necessary' project portfolio, a sequence of projects that make financial sense to all stakeholders. ANSPs aim to ensure a cost-effective and suitable ATM system into the indefinite future. An airline's prime aim is that the business makes cash and does not go bust.

- Need to identify the optimum portfolio – projects sequence that makes financial sense to each of the stakeholders
- SESAR analyses of costs and benefits generally not estimates of the achievable project cash flows but illustrative calculations
- ANSPs' aim is a long-term cost-effective ATM system: must take into account NPV, *and* terminal value *and* very long-term real options
- But airline's aim is that the business makes cash, so focus is on commercial NPV with a ~five-year horizon, plus recognition of Real Options ,eg re investment phasing

Figure 5. SESAR and project decision-making

It is important to note the second bullet point. To quote from SESAR Consortium, (2008a): “In particular, the analysis made at the moment is a "what if analysis" rather than a cost benefit analysis; the output is nevertheless useful, not for taking a decision, but for challenging the assumptions and linking them to the target concept and further on to the implementation packages.”

Figure 6 shows the ATM and SESAR decision feedback loops. Airlines want to have explicit choices and to ‘pick and mix’ projects whenever feasible if these choices improve projected cash flow benefits. It is not shortsighted of airlines to be careful in signing up to major project investments, given the nature of their cash flows.

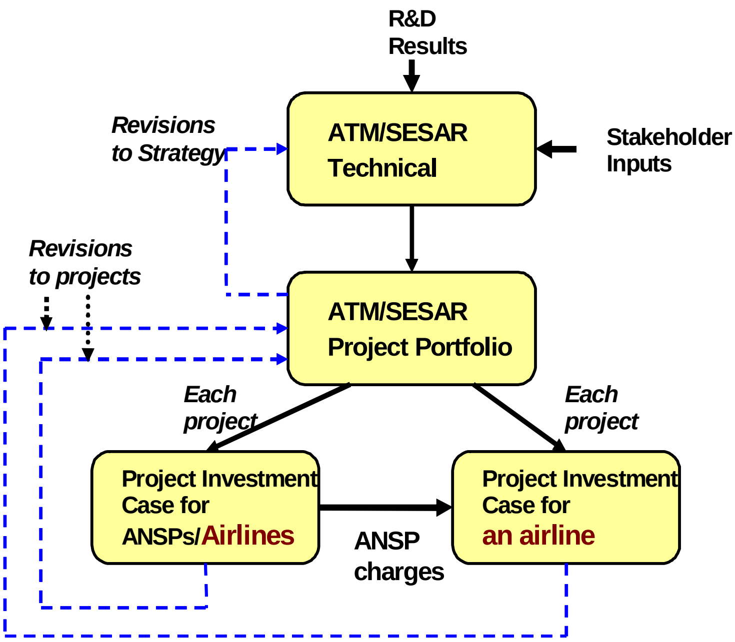

Figure 6. ATM Investment Feedback Loops

Figure 7 illustrates the project-focused financial decision-making for airlines and ANSPs. It shows a highly simplified four-stage process to get to the SESAR endpoint. Each stage, labelled 1 to 4, has several projects, labelled A to C. The labels in the project boxes e shown in differing degrees of emphasis, thus the stage 1 boxes are in bold and the stage 4 boxes are in smaller font. This indicates the amount of financial certainty for the projects. The first stage projects are one for which there are actual contracts; the next stage is projects that are in financial budgets for the coming years; then in stage 3 the projects are specified in a plan but not firmly budgeted; and the final stage contain projects that are currently very ill-defined but which complete the strategic intent. The different colours show where projects are ANSP spend (heavy shading) and a combination of ANSP and airline spend (lighter shading). To get to the strategy-level and SESAR projects, ANSPs/airlines must implement/financially commit to the previous stages.

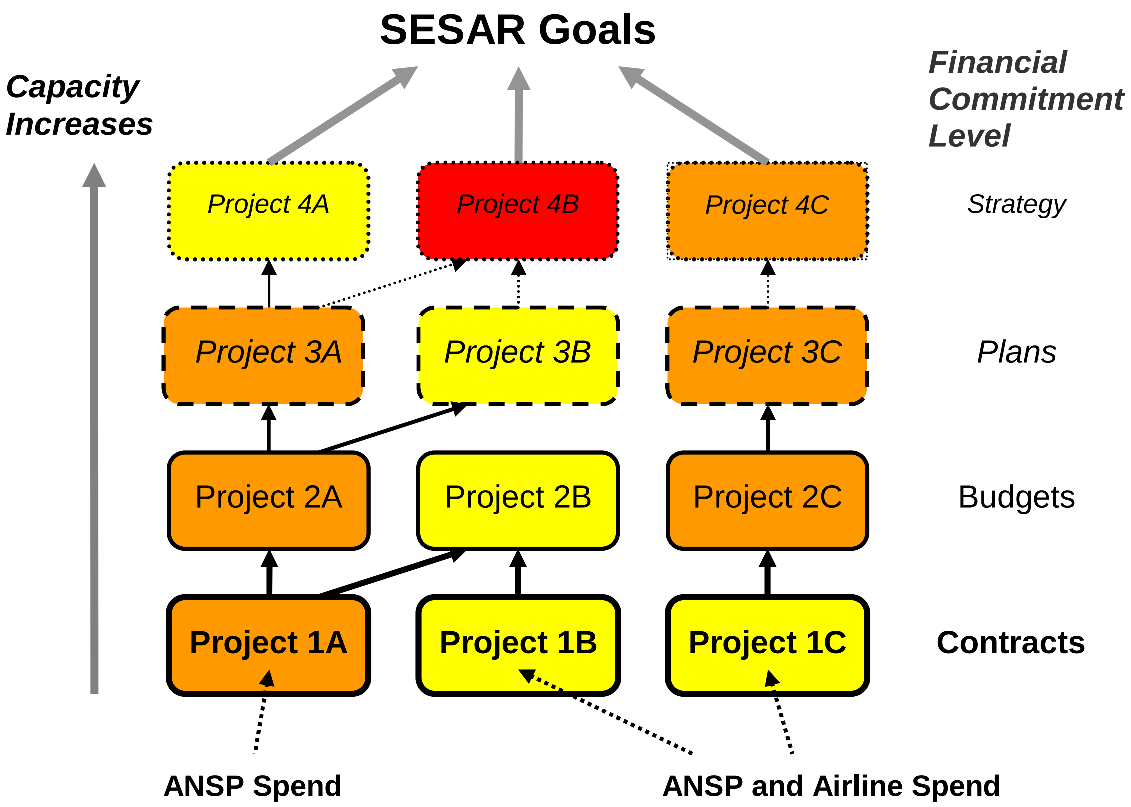

Figure 7. Schematic: Phased Investment decisions

The important message from Figure 7 is that the Contracts and Budget level projects are the *building blocks* for SESAR, so the focus here is on those kinds of pre-SESAR projects. Project linkages matter tremendously. If individual airlines do not decide to put their funding into a project then it *and* its successors disappear: eg in Figure 7, if Project 1C is not funded then the successor projects disappear too. To take a historical example, if airlines had refused to spend money on secondary radar surveillance transponders, all today's radar and conflict alert facilities would never have existed.

7. Pre-SESAR Projects

Figure 8 is a simplified version of a slide used in a very useful Eurocontrol presentation by Redeborn (2005). Table 2 is a description of what these abbreviations mean. Before the ellipse indicating SESAR there are four examples of SESAR 'precursor' activities. DMEAN is essentially 'best practice' improvements, without significant changes to the existing concept of operation. LINK2000+ is a 'critical step toward wide implementation of data-link technologies and applications'. CASCADE: 'ADS-B is recognised as an essential element in SESAR'. ADS-B means aircraft are constantly transmitting their position, flight path intent, and other key aircraft parameters. FASTI 'introduces improvements on controller tools, data interchange and integrity'.

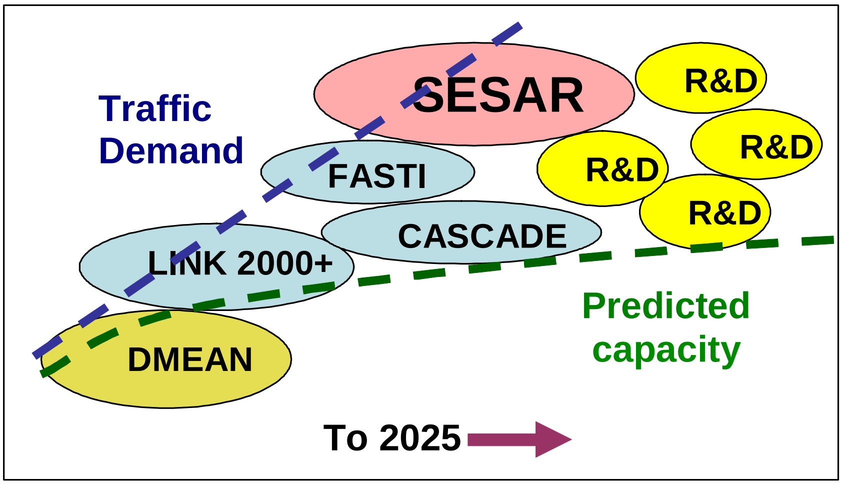

Figure 8. SESAR path

These programmes deliver benefits in their own right *and* are key early components of a SESAR concept for 2025 and beyond. The Table also includes aFDPS, an example of a project that modernises infrastructure to enable the implementation of longer-term SESAR concepts. There are currently 11 European aFDPS initiatives covering 17 ANSPs (SESAR Consortium, 2008b).

DMEAN	Amalgamates current Eurocontrol initiatives in airspace design, collaborative decision-making, Flexible Use of Airspace, Flow/Capacity Management
LINK 2000+	Provides controllers/pilots with second comms channel: air/ground data link
CASCADE	Implementation of ADS-B: for surveillance purposes (ADS-B-out), and for air traffic situational awareness (ADS-B-in) and airborne separation assistance
FASTI	Deploys initial set of controller support tools, meets short/medium term needs & establishes foundation for further automation
aFDPS	*Advanced Flight Data Processing Systems – using new standard for flight data exchange in Europe*

Table 2. Key pre-SESAR Projects

There are varying amounts of cost benefit work done on these projects. There is some good quality data and calculations in authoritative national and international sources. Reality can have markedly higher costs and timescales than planned for (Mott MacDonald, 2002).). DMEAN has few strategic benefits because it is 'best practice'. CASCADE is currently uncertain in term of estimated airspace benefits: is ADS-B a better investment than 'multilateration' for surveillance systems replacement (eg see Dow, 2007)? [NB: multilateration is locating an aircraft's position by computing the time difference signals arriving at multi-receivers] There do not appear to be quantified estimates of the merits of proposed later ADS-B stages at a European level (compare with USA, eg see Scovel, 2007; Lester and Hansman 2007; Marais and Weigel, 2006). It is hard to find aFDPS benefit figures (SESAR Consortium, 2008b). The aFDPS decision is strategic transformational IT.

In summary:

DMEAN, LINK 2000+, CASCADE, FASTI, aFDPS have long R&D histories.

Merits depend on different combinations of NPV, Terminal Value (dependent on growth), and Real Option Value.

CASCADE needs more 'hard CBA' evidence. Multilateration better investment than surveillance systems replacement by ADS-B? Costed merits of later ADS-B stages?

aFDPS investment decision is as key IT software platform, for implementing value-generating applications and reducing the costs of fragmentation.

Projects' software development costs/timescales in practice often much higher than anticipated in plans and early CBAs.

Table 3 shows how the projects measure up against the CBA financial criteria, based on these current 'official' estimates – which may not be robust. To simplify, it is assumed that for airlines the terminal value of projects is effectively zero, so their benefits are through a quick payback and/or the value of Real Options. Remember that ANSPs are spending the 'ATM system' money that the airlines trust them to use wisely, while the airlines are buying new aircraft kit directly.

	Direct Spend by ANSPs *'In trust' for Airlines*			**Direct Spend by an Airline**	
	NPV	**Terminal Value**	**Real Option**	**NPV**	**Real Option**
DMEAN	✓	✓		✗	
LINK 2000+	✓	✓	✓	✓	✓
CASCADE	**?**	**?**	**?**	**?**	**?**
FASTI	✓	✓	✓	✗	✗
aFDPS*	✗	✗	**?**	✗	✗

Table 3. Pre-SESAR Project Valuations (Eurocontrol/ANSP published estimates)
Focusing on en route airspace gains: ✓ = estimated, **?** = not known, ✗ = unlikely.
Sources: DMEAN – SESAR Consortium (2008c), LINK 2000+ – Booker (2007), CASCADE (Dow, 2007), FASTI – Brain (2008), aFDPS – SESAR Consortium (2008b).

8. Economic Context for ATM/SESAR

What is important about the economic context for ATM/SESAR? Several issues arise:

Airline profitability in recent decades subject to large – and increasing – cyclical oscillations.

Now overlaid with chronic oil price shock and credit crunch.

SESAR's goals now appropriate – present economic and oil price position?

Airline costs to increase with EU's Aviation Emissions Trading Scheme (ETS) from 2012 (EC, 2008).

Fuel economy much higher priority, likelihood of a high growth scenario much lower.

Low growth reduces benefits cash flow – need to look carefully at SESAR's flexibility, eg phasing of its project components.

The first two points have already been covered. The ETS costs are probably a much smaller effect than the oil price – but still unwelcome for airlines. A low growth scenario is much more likely. It damages the gains shown in cost benefit analyses. So, how could SESAR adapt to this through project flexibility and phasing?

SESAR currently focuses on high growth scenarios and peak hour loading. A Eurocontrol 'Low Growth scenario' (Eurocontrol, 2004) – still at 2.5% per annum – makes the decision-maker look carefully at project financial benefits and phasing. Under-investment is a bad thing *in the long term*, but financially-constrained airlines will not like actual over-investment.

9. New Runways & Airports and Peak Hour Demand

A critical SESAR assumption is large growth in new airports/runways. Is the right goal a challenging 'peak hour loading' scenario, which might well have a very low probability of occurrence? The implication is the need to assess a range of strategies in terms of the stakeholders costs/disbenefits/benefits from over- or under-investment.

A Low Growth scenario has major implications for the portfolio of SESAR projects. Any projects in the portfolio that deliver capacity above what is projected to be needed or which do not have sizable real options values would be deferred, ie moved up the financial priority stages in Figure 7. A Low Growth scenario would change the available investment budget over the coming years, putting constraints on the number of contracted and budgeted projects.

It is necessary here to explain some aspects of Peak Hour Airspace demand estimation. Figure 9 (left side) illustrates that the summed diurnal demand from a congested – that is 'full' at peak hours – group of nearby airports produces a fairly typical demand pattern over the day, with a flat top determined by the sum of the hourly runway capacities.

Adding one or more new runways produces Figure 9 (right side), with a new airspace demand peak corresponding to the sum of the new set of runway capacities. If there are no new runways then the result is the diagram at the left, in which the extra traffic demand spreads across what were previously shoulder hours, and hence the peak hour demand is unchanged. This is very simplified. In reality, airport slots would get more valuable, average aircraft sizes and load factors would tend to increase.

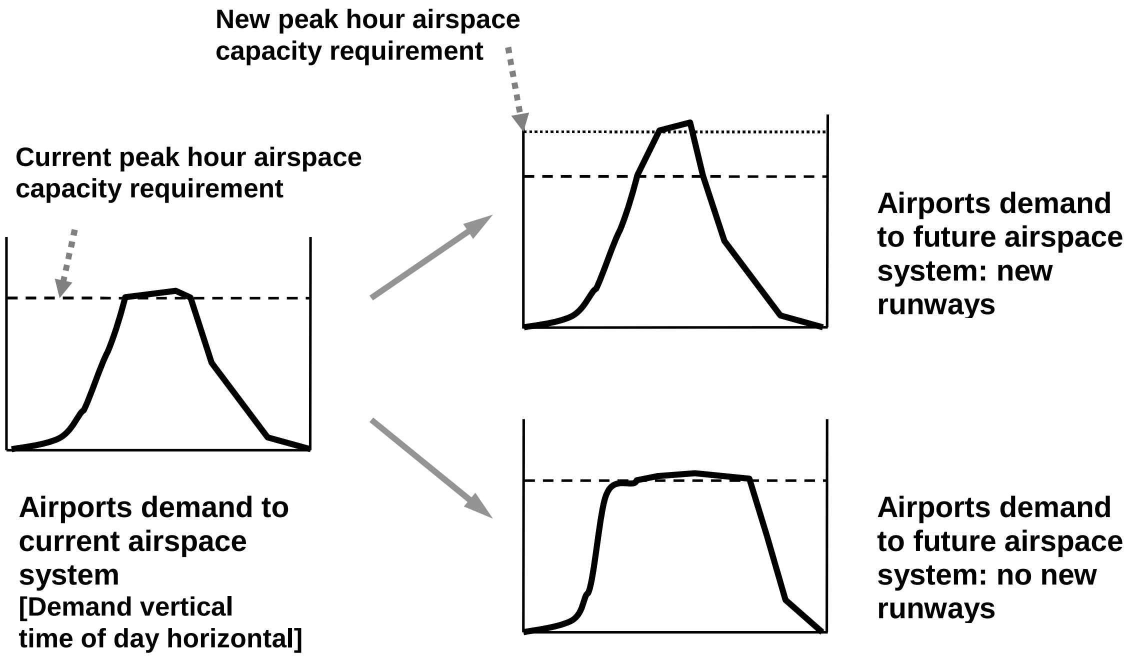

Figure 9. Airports Diurnal Demand Patterns

10. SESAR Planning – Low Growth Scenario

It is vital to examine the context for SESAR planning. Planning for airspace capacity growth has to take place against projections of the future aviation and general business environment. Figure 10 shows the linkages.

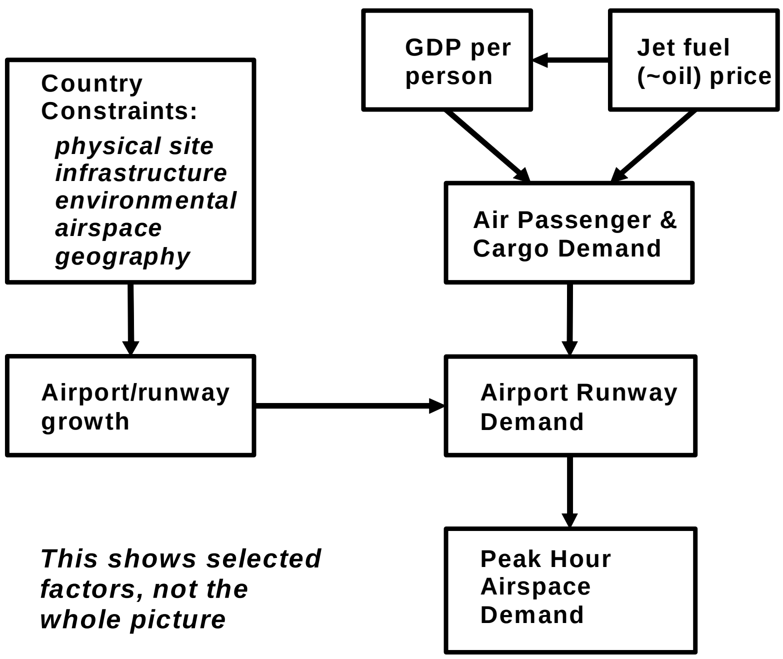

Figure 10. Selected Factors in Predicting Peak Hour Airspace Demand

Air traffic demand only translates into a need for extra peak hour capacity *if* new airports/runways come into service. A reducing oil price is not a good thing if it simply reflects GDP ‘going down the drain’.

It is essential to work through the logical sequence in Figure 10 from an assumption of a Low Growth scenario to the impact on airspace demand at peak hours. Without new airport capacity, the discussions on large increases in airspace capacity are academic, because demand will be constrained by airport capacity. The logic is:

Peak demand is constrained by the airport capacity in use.

Therefore planning for extra airspace capacity requires good projections on the number of new runways.

Therefore, the phasing of existing and SESAR-related projects must take account of fluctuating demand *and* the practical phasing of new airport capacity.

Eurocontrol’s 2004 Challenges to Growth study (Eurocontrol, 2004) attempted estimates of constrained demand if major new commercial airports were not developed – will they be?

Low GDP growth and long-term high oil prices generate an ATM Low Growth scenario.

The simple conclusion is that setting the phasing of new SESAR related projects to deliver airspace capacity gains must take account of fluctuating demand, likely GDP growth, oil prices, and the practical phasing of new airport capacity.

What are the quantitative implications of the Eurocontrol Low Growth scenario for SESAR requirements? The easiest way to see this is to present some crude sums about the capacity gains from some of the pre-SESAR projects. These are all from official State and Eurocontrol cost and benefits analyses, not a reworking of the calculations.

DMEAN plus air traffic flow measures together produce an airspace capacity increase of 24%-32% (SESAR Consortium, 2008c).

CPDLC at 100% fit is estimated at 14% improvement (Booker, 2007).

FASTI generates gains of up to 15% (Brain, 2008).

Thus, in combination, the sector capacity gain would be substantial: between 63% and 73%: This is about the amount required for a Low Growth scenario to 2025 (Eurocontrol, 2004).

Thus, taken as a whole, a rough figure across Europe, these pre-SESAR projects deliver the bulk of the capacity needed on a Eurocontrol Low Growth scenario to 2025.

11. Conclusions

The key financial point is that a typical airline has to work hard to survive and needs quick paybacks on investment. The key decision-making point is that ANSPs act as agents for airlines as a whole.

The analysis here has identified the following ATM/SESAR 'best value' Issues for airlines:

- European GDP, traffic and airport growth?
- Oil impact?
  - Fuel economy
  - Climate change (taxes and ETS)
- Financial Decision making criteria
  - NPV – ANSP/'airline agent' and <u>an</u> airline cash flows
  - Real options
- ATM Growth potential using 'existing' technology
- Project choices & sequences
- R&D and project linkages

Examples of the kinds of strategic decisions these would imply for SESAR planning are.

- Must recognise real complexities of aviation financial & operational decision making.
- Must provide hard evidence to airlines about returns on investment and value of options [cash flow!].
- Must implement mature pre-SESAR programmes with major business benefits & real options for stakeholders – these secure the 'Low Growth' future.
- Must keep SESAR Europe-wide momentum.
- Examine SESAR priorities: create R&D/project portfolio assuring CBA on cash flow paybacks & maximising future real options value – build system framework that can meet higher demand by re-phasing.

Note: this is a condensed version of a paper in preparation

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