AIR TRAFFIC MANAGEMENT INNOVATION AND UK BUSINESS OPPORTUNITY

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Abstract

ATM (Air Traffic Management) and the associated UK business opportunities are huge topics, so the presentation sketches key issues. It includes lessons from the past, some ideas about the future, and case studies. The ATM system is big and complicated, so innovation has to combat system inertia. Two complementary 'New ATM paradigms', SESAR and NextGen, aim to break out of the limits inherent in the current ATM system. To innovate successfully in ATM, be part of the planned future that actually gets developed, and/or create/fill a need that is not yet in the plans. p.brooker@cranfield.ac.uk

1. Introduction

ATM (Air Traffic Management) and the associated UK business opportunities are both huge topics, so the following is a sketch of key issues. It includes some lessons from the past, some ideas about the future, and a couple of case studies.

2. History

The picture 40 years ago: Figure 1 shows key conclusions from the UK's 1968 Brundrett committee about what the UK system would be in the late 1980s and beyond. This technology forecasting had mixed success. The world does not have supersonic transports and VTOL aircraft: noise, economics of operation, competitive edge over other modes, are big problems. By "sectorized" they meant that Heathrow traffic would go to the west and north, Gatwick to the south and east, etc, to simplify the ATC problems, ie airlines tell passengers where to go rather than the aviation system meeting demand.

The focus then was on future technology rather than customer benefits and financial rewards. Environmental issues – mainly noise then, but with climate change concerns now – can be critical constraints. The ATM system is big and complicated, hence there is a great deal of system inertia that innovation has to combat. Changes need to be safe, necessary, and offer a good investment payback.

3. MLS

An example from the history of landing aids shows some of the key factors in ATM innovation. This is Microwave Landing Systems – MLS. In the 1960s, people saw the limits of the Instrument Landing System (ILS) as major problems: limited number of VHF/UHF channels, susceptibility to signal reflection – multipath – errors, only straight courses in for landing. MLS was seen as a 'more capable and flexible landing system'. After many years of R&D and testing – and arguments in ICAO – there was a decision in 1978 to adopt the 'proven technology' of 'TRSB-MLS'.

But, although the major airlines had initially pushed for the development of MLS in the late 1960s, they were in practice less enthusiastic about implementation; mitigations were found for some of the ILS problems, and airlines' financial concerns made them reluctant to purchase new avionics without immediate operating benefits. In the UK, operational research work (eg Brooker, 1987) showed that MLS benefits at major airports, because of reduced Localiser Sensitive Areas near runways, were valuable, but constrained by controller workload in bad weather conditions. The 'flexible' applications of MLS, eg curved approaches, were difficult to apply in the UK.

The FAA awarded an initial contract for 178 of 1,250 Cat I MLSs to the Hazeltine Corporation in 1984. But only two of these 178 systems were ever delivered – Hazeltine ran into problems with software and the FAA cancelled the contract in 1989 (Wallace, 2007). Then the availability of GPS as a landing aid in the early 1980s exacerbated MLS's worldwide problems. Very early on, engineers knew that augmented GPS could deliver Cat 1 landing guidance. The continued availability of good ILS and the potential for GPS now seems to have squeezed out the world-market chances of MLS. The UK still has an MLS programme, with an installation at Heathrow (Evans, 2003). There is a market for Multi-Mode Receivers, capable of operating in ILS, MLS, GPS, etc modes.

MLS shows the potential complexity of the technology implementation process. There were 10 years of delays and obstacles following the ICAO decision. The world-wide need for that specific technology largely went away, because ILS got better and GPS became available. 'Flexibility' benefits turned out not to produce hard cash for airlines – they focused much more on quick investment paybacks.

4. Key Tests for ATM Innovation

Safety is always the top priority in the introduction of new aviation systems. The present system relies for safety on a complex combination of hardware, software and 'peopleware'. It delivers safety because it has built up these layers of defensive safety barriers. But safe innovation gets harder the more there are linked and integrated systems (Brooker, 2007). 'Five plus One' Key Innovation Tests are:

- Safety Credibility
- Operational Concept
- Technological Feasibility
- Benefits and Costs
- Transition Path
- ***Decision-making Process***

These are all obvious to some degree. It is hardly a surprise to hear that technology has to work to stand any chance of being introduced!

But there has to be a realistic transition path from the present system. Does the transition path make sense in both safety and business terms? The international dimension is a major factor, given the lengthy formal processes of international development, testing and certification. If the ‘old’ and ‘new’ systems are operated together over a long period, then operational benefits can take a long time to appear. The longer this process is, then the more likelihood that something can go wrong.

The phrase Operational Concept means no more than a clear picture of *how* the future system would operate. Who uses what information to do what things? What are the responsibilities, and on whom do they rest? How are decisions made? ‘Flexible operational concepts’ can turn out to be unattractive in terms of the actual ‘hard cash’ gains to customers.

Aviation benefits can be of many kinds. The whole aviation industry treats safety as its paramount objective, but increases in airspace capacity and reductions in operating costs, eg through more fuel-efficient flight paths, are very valuable. But valuing these future gains with reasonable precision can be extremely difficult. Do the benefits outweigh the costs when a full business analysis is done? Who gains what and when – and how far distant are the gains from the monetary investment? How robust is the benefits case if there are system changes?

The ‘plus one’ item – Decision Making Process – is therefore crucial. It is essential to look hard at the reality of why and how people make decisions to do things. For example, in Figure 2 – buying a television – some decisions are ‘economic’ in the normal sense of the word. Others are ‘no choice’ ones: eg if television is no longer broadcast on analogue signals you have to buy a new digital one if you want to keep watching. The reality of big problems like ATM is the same as this – just more complex. Political things have to be added: national prestige, security, defence, keeping a country’s employment in high technology industries. This is why there are often political – in the widest sense – incentives to change equipment (eg see Marais and Weigel, 2006), the ‘big picture’ being that equipage that shows an overall positive value can nevertheless fail to provide value to individual stakeholders.

5. Forecasting

To innovate successfully requires forecasting how the Key Tests are going to work out. The equation confronting the innovator is:

The Future	=	What is planned to happen
	-	Plans that don’t get implemented
	+	New things that people discover they want

Only the current plans are known, sometimes not very precisely – there may not always be a specific technical solution or a firm idea about the kinds of multi-stakeholder decision processes that will need to succeed. What actually happens can depend on many things. Figure 3 shows some possible scenarios.

The black scenario in Figure 3 assumes that current ATM plans – which include new system paradigms – are implemented. The major problem is that it could cost more and take longer than people’s early estimates, producing the dashed line, mainly because of programme difficulties and financial assessments. That is nothing more than what the history of ATM over the last 25 years tell us – Table 1.

The vertical scenario overlays the current plans with the consequences of catastrophes. An example is TCAS. If the USA had not been so concerned about mid-air collision and its Congress had not made such a firm commitment to the introduction of collision avoidance systems, TCAS would not have been implemented world-wide. It there had not been the Tenerife runway accident in the 1970s the pressure for airport ground radar and subsequent surveillance developments would not have been as strong. September 2001 is a different kind of catastrophe, one that adds security dimensions into ATM: if this aspect turned out to be an increasing problem, then there would be changes adding new elements to the ATM paradigm, eg Figure 4.

Figure 3 also shows a ‘No new paradigms’ future. This is a situation in which the aviation industry becomes much more conscious of resource problems, perhaps because of economic downturns, or much higher fuel costs, or the imposition of climate change taxes/permits, etc, etc. The famous quotation attributed to Fausto Ceruti – then the AEA Chairman – goes: “The airline business has all features of businesses - apart from profits”.

6. SESAR and NextGen

There are two complementary ‘New ATM paradigms’, SESAR and NextGen, with the aim of breaking out of the limits inherent in the current ATM system. These represent ATM’s strategic directions. Note that the two systems must have aligned requirements for equipment standards and technical interoperability.

SESAR is the European ATM modernization programme, focused on 2020. Its first phase is the Definition Phase, which is co-funded by Eurocontrol and the European Commission (Trans European networks). A major ‘SESAR Deliverable’ was the ‘ATM Target Concept’ – a vision not a plan, and certainly not a final blueprint of the future system. The basic idea behind the SESAR Concept is to structure ATM around aircraft ‘Trajectory Based Operations’. This is not a new idea, but its time seems to have arrived because of actual and potential system developments – Figure 5.

Note that some of the SESAR ingredients – key enablers – have been the subject of continuing R&D work and international standardisation for the last twenty years. One example is VDL Mode 2, for air-ground data linking, and there are other ATN improvements and services (Sharma, 2007). ADS-B (Automatic Dependent Surveillance - Broadcast) is a core technology enabler – essentially through aircraft text messaging. ADS-B equipment has been extensively and successfully tested in operational environments, and is an example of a developed SESAR and NextGen technological component.

The SESAR ingredients include:

- Business Trajectory at the System Core
- Trajectory Management Focus
- Collaborative Planning

- Integrated Airport Operations
- New Separation Modes
- System Wide Information Management (SWIM)
- Humans Central as Managers and Decision-makers
- Technology Enablers

The Concept document expands on this.

Figure 6 shows a very simplified picture of NextGen emphasizing the 'cooperative surveillance' model for civil aircraft operations, ie with aircraft constantly transmitting their position, flight path intent, and other useful aircraft parameters. SESAR currently appears to be more general than NextGen. The main difference is that NextGen additionally uses automation through the Evaluator function to analyze these trajectories, thus ensuring that aircraft remain at safe distances from one another.

7. SWIM

A key element of both SESAR and NextGen is SWIM. Figure 7, derived from an authoritative USA document (Sayadian and Weill, 2004), illustrates the nature and scope of SWIM. It provides the infrastructure and services to deliver network-enabled information access to a multitude of ATM system users. SWIM must successfully integrate with a variety of legacy sub-systems over a period of many years.

There are two special reasons why SWIM is very complex and very big – and hence why it will not be cheap. First, because it is crucial to operational safety and efficiency, performance requirements and safety certification will be very demanding. Second, because of the need to have a secure ATM system against terrorist attack and to protect the military users of SWIM and SESAR generally, SWIM will need to meet the highest category of State and European-level security requirements.

R&D expenditure into SWIM so far in Europe and the USA has been no more than tens of millions of Euro/dollars. The European implementation project will be a large chunk of future ATM investment, certainly into the billions of Euros, so it is potentially a technological area with many business opportunities.

8. How to make Money by ATM Innovation?

Innovations have to make money. Actual implementation has to be successful. These are obviously huge topics in both technology R&D and business strategy. Amazon lists over two hundred thousand books under 'innovation' and Google offers 88 million sites. Most innovation lessons from reputable sources apply equally to innovation in technology-based industries (eg Andrews, 2006), especially regarding resolving intra-organisational issues and the benefits of partnering and collaboration, but ATM does have its specific features. What are the ATM commercialisation paths? To make money from innovation in ATM: first, succeed in being part of the planned future that actually gets developed; and/or second, create or fill a need that is not yet in the plans.

Some simple Figures help to illustrate key ATM innovation points. Figure 8 starts with a old proverb about money. It then notes that there are large gross profit margins for successful industry firms – the figures here come from the Chief Executive of such a company. There are a limited number of big firms in the European ATM business – Figure 9. To grow to be a big firm is very hard, because of the ATM industry's entry barriers for smaller business entrants – Figure 10. But subcontracting for a big firm in a niche area offers possibilities.

But ATM Small and medium enterprises (SMEs) can grow considerably by themselves, taking strong positions in evolving markets. An example is the Era Corporation (was Rannoch Corp.), which is now a successful international ATM business http://www.erabeyondradar.com/media-coverage/. Rannoch Corp. was co-founded by Alex Smith in 1991; Alex had previously worked for UK NATS on several air traffic systems programs, and the for Booz Allen and Hamilton. The company has:

> 'Forged a meaningful and significant role for ERA in the global aviation flight tracking and airport management business… pioneered the use, acceptance and necessity of real-time flight tracking and aircraft identification technologies for a variety of new and innovative market areas.'

Era Corp. offers products using sensor-based surveillance and flight tracking systems, including:

- Multilateration and ADS-B co-operative technologies for surface movement, terminal area, and wide-area en route ATC applications
- AirScene (integrated airport management system platform) to provide support for business functions – revenue management, gate allocation, noise management
- Surface and terminal area range management solutions for military/homeland security

Some of these technologies were actually FAA-funded research laboratory activities 15/20 years ago, eg multilateration was studied in Lincoln Laboratories. The Era Corp. achievement has been to use this 'knowledge base' to develop marketable, low-cost products which can be integrated with (eg) controller display systems. Key elements here for SMEs are the degree to which ATM systems need to meet international technical standards and the importance of sub-systems interoperability.

9. Conclusion

ATM innovation is a tough business. It is tough because accurate technological forecasting is tough. But the planned changes to new ATM paradigms offer greater SME opportunities, either for subcontracting to large industry firms or by creating/filling a need for attractive new products in specific technical areas.

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- Continued growth of civil air traffic at ~ 4% pa
- SSTs in widespread use on long-range overseas routes
- VTOLs between city centres and between city centre and airport
- Sectorized operation from three London airports (and a fourth being considered)
- Automated ATC -> reduced separation standards, area navigation routeings, automated air/ground communications
- CAT III operations at major airports
- Aircraft with integrated systems concept flight deck designs to reduce pressures on aircrew
- A single ATC organization for Western Europe

Figure 1. Projections for late 1980s (Brundrett Committee into Civil Aviation R&D Objectives, 1968)

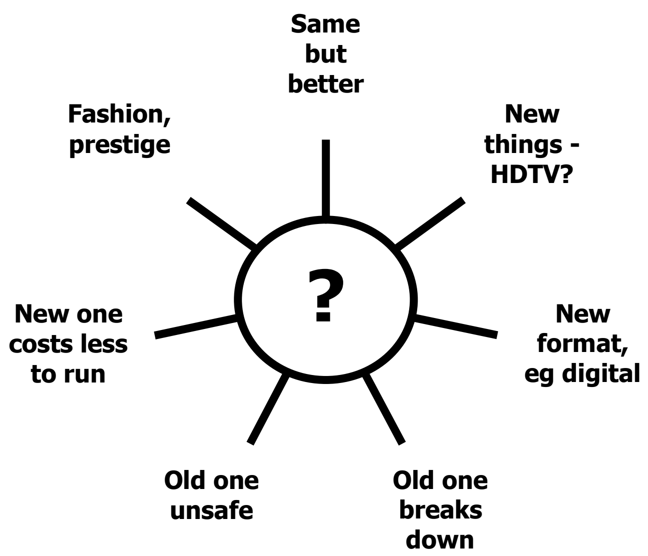

Figure 2. Why buy a new television set? Decision Making Process

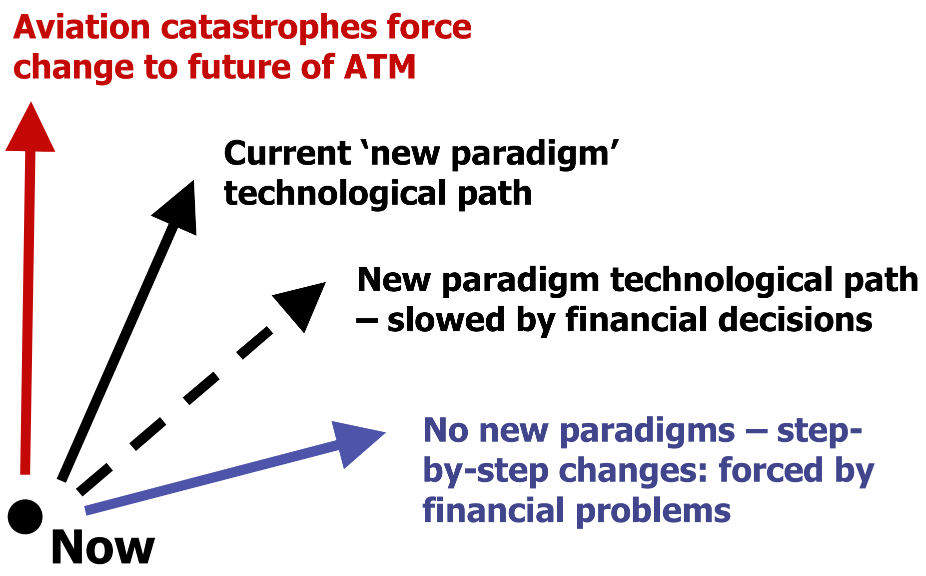

Figure 3. What could happen? – ATM scenarios

- Downlink of audio and visual from the cockpit and cabin
- Provision of a dedicated resource for telemetry, so know what the aircraft is doing, and possible control of the aircraft
- Need operational concept to cover both security measures and the security mechanisms designed to make ensure 'normal' safety
- Likelihood of such things being implemented; impact on operations, testing, certification?

Figure 4. Post Security-related Catastrophe(s)? Security measures supported by datalink.

Highly accurate satellite positioning systems

Accuracy/reliability of aircraft-achieved 4D trajectory

Accuracy/speed of passing information via data link

Huge improvements in surveillance capabilities

Automation and Decision Support Tool capabilities

Huge improvements in computer/equipment processing power and speed

Maturity of 20+ years R&D work (eg VDL Mode 2)

Figure 5. Why a 'New Paradigm ATM' SESAR?

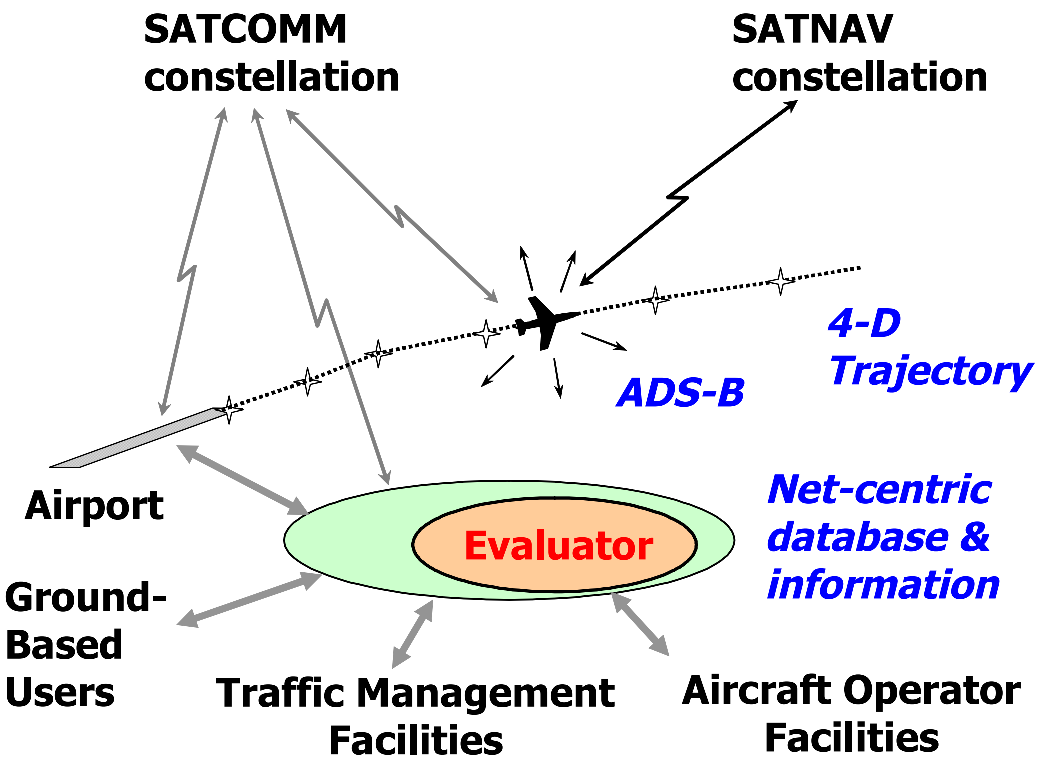

Figure 6. NextGen schematic

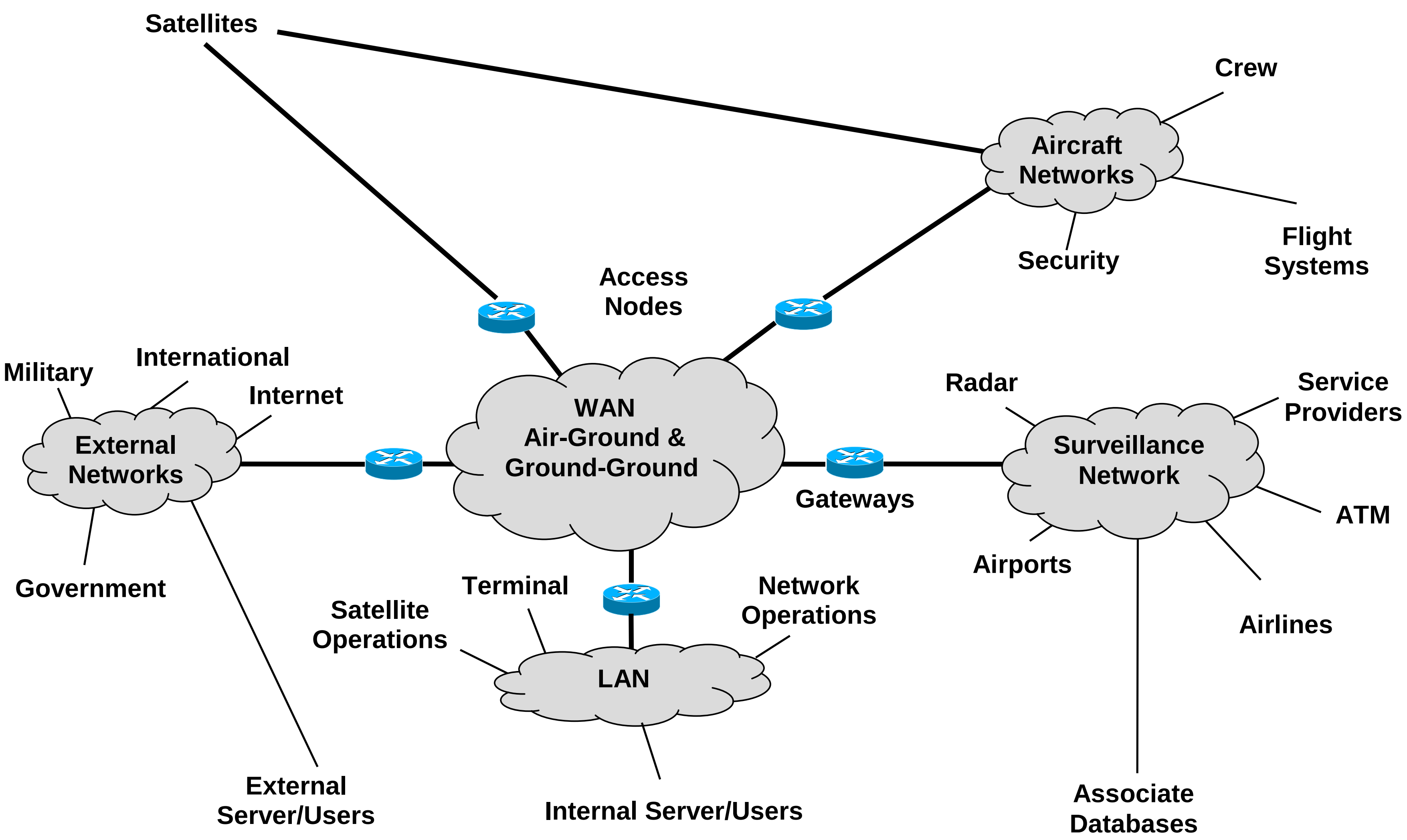

Figure 7. System Wide Information Management (SWIM) Schematic: adapted from Sayadian and Weill (2004)

Old proverb:

"It takes money to make money"

Typical big ATC company Gross Profit Margins:

Automation system work ~20%

FDPS software ~30%

Figure 8. Where is the Money?

Global ATM systems & equipment “market” including avionics, control centre systems and the enabling CNS infrastructure is estimated at about €1Bn per annum in Europe.

Main suppliers are:

- Raytheon
- Thales
- Lockheed-Martin
- Selex
- Honeywell
- Rockwell-Collins
- Indra

Figure 9. ATM Supply industry (SESAR Consortium, 2006)

- Investment
- Intellectual property
- Economies of scale
- Globalisation – global players already present in local market
- Customer loyalty
- Research and development – upfront investment in technology
- Supplier/Distributor ‘exclusive agreements’
- Cost advantages independent of scale – proprietary technology, know-how, learning-curve advantages

Figure 10. Examples of ‘Barriers to Entry’ factors favouring very ATM large firms

	UK (NATS)	Canada (Nav Canada)	Netherlands (LV NL)
	NERC	CAATS	AAA
Contract value	£475M	$377M	$35M
Final Cost / Contract	1.3	1.3	1.7
Original Planned Duration	6 years	6 years	2.7 years
Actual / Planned Duration	1.7	1.8	1.6

Table 1. ATC Centre System Development comparisons (source: Hutchings and McCulloch, 2004)