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FUTURE AIR TRAFFIC MANAGEMENT SYSTEMS AND RATIONAL ACTORS

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1. INTRODUCTION

If there were just one person in charge of World or European air traffic control (ATC), who had all the money, made all the decisions, project managed all the implementation of new technology and procedures, etc, then life would be easy and the future would be simple. But there is not such a person. There are several different kinds of 'rational actor' in this drama; actually groups of people each having very similar interests. They are termed rational because they make decisions in what appears – to them – to be a rational manner. So how does this affect the development of ATC?

2. THE PROBLEM

The following deals only with en route ATC, ie away from airports and their special equipment and procedures. The concern here is with the strategic future of the 'Air Traffic Management (ATM) system' rather than marginal progressive changes to the present arrangements.

The problem is:

- There is an ATM system now
- It is not perfect.
- Present problems are projected to get much worse with increased traffic.
- What should the future ATM system in 10-20 years be like?
- How are the transitions going to be made? What are the steps involved?
- Who has to be persuaded – and how? – about what to do to make the transition steps

The key thing to remember is that the ATM system is there to prevent mid-air collisions. It does that by imposing certain system constraints on flights. In simple terms, these are:

- Controllers use flight plan data and radar to keep aircraft apart by minimum separation distances horizontally and vertically.
- Aircraft fly largely fixed routes through controllers' blocks of airspace (sectors), rather than direct flight paths, so that the number of potential conflict points is reduced.

- This enables the mental workload on controllers to be minimized.
- But there are still limits on the hourly traffic that a controller can handle in a given airspace sector if workload is to be kept acceptably safe.

Three unpleasant and sizable ATM by-products are manifested:

A: Direct costs to users of supplying ATC

B: Extra flightpath distances – and hence costs – from indirect routeing

C: Delays caused by demand/capacity mismatches – and hence costs

The future ATM system, denoted here as the scenario, has to do something about the total of the costs A to C – termed here the 'ATC-related costs'.

Cost Benefit Analysis (CBA) is said to produce rational decisions about options to deal with such things. But it is a particular kind of rationality. Thus, there are pluses and minuses, which can be costed and combined through as specific calculation scheme, generally focusing on flows of hard cash. The CBA-orientated decision-maker may look far into the future, but still keeps a close watch on his/her wallet.

3. RATIONAL ACTORS

The following descriptions of rational actors are based on fact and observations of behaviour. There is some interpretation and supposition: 'If I were in their shoes, how would I make judgements?' The actors covered are airlines, ATC providers (and Economic Regulators), Controllers, R&D, Industry, Safety Analysts, ICAO, Government, and European Planning. There are others – pilots, obviously.

Airlines

Airlines generally do not make big profits. They often go out of business in the industry troughs and because of cutthroat competition. They have tough shareholders and bankers. So they pay very close attention to real money flows – 'hard cash'. They do not take a long-term view: payback on investment, perhaps no more than a couple of years ahead.

They want to be safe. But they will want proof that new safety technology significantly reduces risks. They will want to see the safety and financial sums. They prefer to see such technology mandated by ICAO, so that their competitors face the same cost burdens.

They are happy to introduce new technology to save ATC-related costs. But they have had bad experiences in the past. They were told that new area navigational equipment ('RNAV') would provide them with direct routeings – but it generally did not. They do not like what they have heard so far about satellite systems such as Galileo, because they seem largely to be technology-focused rather than offering means of reducing ATC-related costs.

Airlines have become increasingly careful in their dealings with ATC providers. They have usually seen the costs of ATC going up. They have often seen investment projects cost far more than promised and several years late. Many feel that ATC providers have been sheltered from the real commercial world.

ATC Providers (and Economic Regulators)

ATC providers are increasingly viewed as commercial businesses. In practice, they are monopolies, regulated in different ways in different states. The European Single Sky is intended to introduce 'more rational' airspace designs, not necessarily bounded by states' borders. This potentially could lead to competition by ATC providers for pieces of airspace, possibly on a franchised basis.

There is already pressure on ATC providers for 'financial transparency' and the performance of each ATC provider is being compared – benchmarked – with others in Europe and with the USA. This leads to pressure on staff costs and induces some cooperation between states on development work. However, the pressure is generally on current cost-efficiency rather than innovation to produce a cost-effective future ATM system. Regulatory methods, eg the use of 'Price Index – x' processes for ATC charges, tend to assume that the key aim is marginal (in the economic sense) improvement. This includes better use of resources, staff efficiencies and 'risk free' investment programmes, mainly consisting of replacements and 'slightly better functionality' upgrades.

In the regulatory literature, there is very little on any linkages between 'Price Index – x' and strategic innovation. On investment, the regulatory focus generally tends to be on cash flow analysis rather than strategic issues, so again short-term improvement tends to be favoured over long-term innovation.

Controllers

The word 'controllers' here means operational controllers, who plan or control daily traffic flows. Controllers are generally in secure jobs with reasonable salaries and pensions; and with shift work hours being tightly regulated. Their skills are not readily transferable outside the ATC field, so comparatively few leave to do other things.

The prime factor in determining the capacity of a specific en route sector is actually the mental workload of the controller. He or she has to process and retain information on flights whilst maintaining the mental picture of potential conflicts between flights.

Controllers would not be expected to rush to implement things that would put them out of a job. Nor would they be expected to rush to implement changes that de-skill their role. This is a problem with computer assistance: if the controller is presented with a proposed conflict solution then where is the skill in just agreeing to it? Given the necessary information, the software can find solutions to routeing problems that are going to be as good if not better than the controller's. [This may require some kind of 'expert system', which distils the rules of thumb and strategies used by expert controllers.] If the controller's job if just to sit and watch the screen until something peculiar happens – which would happen less and less frequently as computer systems are bedded in – then the job becomes rather tedious.

R&D

There are programmes of ATM-related Research and Development (R&D) in ATC providers, Eurocontrol, universities, government-sponsored research organisations, and aircraft manufacturers. R&D staff want to see their products implemented – but also want to explore many possibilities in depth.

The strategic goal is to find ways of reducing the increasing costs A to C, noted at the very beginning. This means that the concept of 'control' must be changed. The main aim is to tackle the present system constraints – the 'workload bottleneck' – that lead to the unpleasant ATM by-products. This has to be some combination of:

- Transfer of control/separation tasks to pilots
- Reduction of workload by computer assistance, eg displaying potential routeings and/or conflicts
- Elimination of tasks by major redesign/transferring them to computer software

None of these is painless: at the very least, aircraft need new kit or ground computers new software. One of the major issues is the extent to which information from the aircraft's computer systems – which increasingly contain data about the next position ('waypoint') to which the flight is travelling – can be accessed. If this waypoint data is available for conflict probing then the frequency of false alerts, generally caused by simply assuming that the flight is continuing on its present course, can be reduced considerably.

R&D people can suffer from the 'hammer fallacy', ie 'I have a hammer, so I see everything as a nail'. Thus, experts on workstation displays see the solution through – improved displays. Experts on pilots and cockpits see the solution as transfer of tasks from controllers to pilots. Satellite navigation experts might well see the key ingredient as positional accuracy. But which of these makes most sense in terms of the controller's workload and the ATC operational concepts in use (compare the constraints picture in Section 2)?

Industry

Manufacturing firms exist to sell engineering products and make profits from doing so. Some parts of the aviation industry can take a long-term viewpoint, eg aircraft manufacturers. However, the sums have to add up, eg R&D costs have to be recovered from sales income; and the rate of return on innovation must – overall – exceed the firm's cost of capital (unless there is subvention from Government).

R&D costs are a major problem. If they are substantial then the production run has to be large enough for them to be fully recovered. If the run is potentially small then the unit cost may put the price up to a level that deters buyers (who have to achieve savings exceeding the costs of the equipment). R&D costs that are estimated to be very large have a habit of turning out to be even larger in practice, particularly so if most of these costs involve software development, testing and integration.

ATC Centres with new software/hardware systems, requiring substantial development work, are not that attractive to industry. The risks of cost overruns are high, which inter alia leads to legal/contractual problems and the risks to firms' reputations. Past European and USA ATC requirements, project management and software difficulties are well documented in the literature (but other high technology industries have similar problems).

Given the limited number of implementations of ATC Centre software in any one country (apart from the USA), it would be poor business practice to develop different software in different countries. So, future ATM software would need – at least – to be developed with high confidence that it would be used in several other countries. However, this brings up political issues about commercial tendering and 'national champions' in engineering.

Safety Analysts

The phrase 'safety analysts' covers a range of different kinds of people and responsibilities, some 'wearing a regulatory hat'. The common thread is the need to demonstrate that a future ATM system will be safe, ie pose risks to passengers that are certainly no greater than the present system. Some of these people will be regulators but most will work for ATC providers. The range of activities involved will range from design engineers to risk calculators to human factors experts.

ATM safety is now very good, which means that the targets, processes and procedures for changes in ATM have to be very rigorous. Rigor implies a detailed understanding of a new system coupled with numerical targets for performance. There are now very few ATM accidents resulting from hardware failure: the major concerns are with invalid pieces of software logic and human failures. The most difficult areas are those in which human factors are required. In particular, the understanding of control workload for a new scenario is not straightforward – present workload models are crude design tools.

It takes a substantial amount of effort to prove that even a simple (in concept) operational change ensures the necessary safety. An example is Reduced Vertical Separation Minimum (RVSM), where a simple change in the separation minimum for high-level flights involved many years of data collection and risk modelling. This is the key problem for a new ATM scenario: the safety analysts must do the job properly; this takes several years; not everything is known and 'on the shelf', so risk models must be created and filled with data.

Safety analysts are not primarily concerned about the cost of different options. They will test out any option on the same general principles. Their kind of rational action means that exploring multiple possibilities could take a very long time. People can do things in cleverer ways, but there can be no safety shortcuts.

ICAO

ICAO does many things, but, in the present context, it is a standards organisation. As a country's ATC has to deal with aircraft from other countries, any major changes in ATC have to involve international standardisation. This generally operates at what many would see as a slow pace.

For example, airborne collision avoidance systems (ACAS) were developed in the early and mid 1990s, but were not endorsed by ICAO until 1993 and were not fitted to the bulk of commercial aircraft until the end of the decade. Part of the reason for this timescale was the need for the USA to convince other states that the system that it was proposing would achieve the necessary safety. Another factor was the time it takes to reequip aircraft: this is usually done when the aircraft is undergoing major maintenance rather than just taking it out of service.

Government

The role of national Government in ATM has changed considerably over the decades. Once, ATM was a governmental function in all European countries. Now, some ATC providers are privatised or corporatised, and safety and economic regulation may be one step removed from Government. ATM is largely expected to pay for itself; indeed elements of en route charges are sometimes used to pay for regulation and to contribute to Government costs.

Governments can intervene in ATM for political reasons. For example, in the European Single Sky developments it has been Governments – advised by ATC providers and regulators – that have taken the lead in working with the European Commission. Governments can also use ATM as a means of pursuing industrial strategy either nationally or internationally, eg instructing (or leaning on) ATC providers to agree to cross-European industrial projects.

European Planning

ATM planning is one of Eurocontrol's functions. The ATM scenario kind of work is described in the ATM 2000+ documents. For the period 2010 to 2015, the aim is for the 'Redistribution of tasks between the human and the machine…between the air and the ground, to improve levels of productivity'. However, the 'Plan' at present generally consists of a very large technical and operational list of possibilities: no particular technical path appears to be completely ruled out.

The difficulty for Eurocontrol is that it is not the single decision-maker. It is a consensus building organization. It tries to be inclusive and keep options open until there is agreement about the way forward. Its strategic plans are positive intents to do 'something', but without the financial and business commitment to spend money, to buy particular pieces of equipment/software for aircraft and Centres, and to change particular operational practices at particular times.

4. YOU WERE EXPECTING A CONSTRUCTIVE CONCLUSION?

Painting the picture of rational actors is one thing, but resolving the major conflicts between them is another thing entirely! A Web search will reveal over a million sites on the topic of conflict resolution – which rather indicates the difficultly of the problem in society and business.

The most important thing to recognise at the outset is that these are intrinsic conflicts between actors with genuinely different interests. It is not sufficient to suppose that (eg) the 'invisible hand' of market forces will lead to better ATM systems. There will be monopoly provision of ATC services even with Single Sky ideas.

Conflicts are generally resolved by real negotiations in which there is open discussion of the rational actors' interests, including reasons, needs, concerns and motivations. At some point, it is essential to concentrate on real technical and investment choices: all options cannot be kept open indefinitely, to the accompaniment by endless 'analysis paralysis'. It is essential to focus on a few choices that deliver big paybacks on robust assumptions – this may mean that a great deal more work is required to get high quality information about benefits and costs. Money will always be a major problem: how can the actors be prevented from endless argument about a fixed pot – a zero-sum game?

To break the zero-sum game, could Government, probably at a European level, play a much more positive role? Could it direct regulators to press for strategic changes? Could it offer funds at low interest for strategic investment by ATC providers and airlines? These would be investments that delivering benefits to passengers for decades hence, currently squeezed out by the short-term cash flow considerations. [NB: they would not be funds pumped into manufacturing firms for industrial policy reasons.] Government would put back into decision-making the choices that these future passengers would like to make about ATC-related costs. This would put ATM on a level playing field with other transport modes.

Further Reading

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