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REVOLUTIONARY VERSUS EVOLUTIONARY STRATEGIES: THE FUTURE OF AIR TRAFFIC MANAGEMENT SERVICE PROVISION FROM A SUPPLY CHAIN PERSPECTIVE

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EXECUTIVE SUMMARY

When dealing with the issue of the air traffic management (ATM) future, prominence is generally given to technological change. Paradoxically, there is agreement in the industry on the fact technology is not the main driver. Against this background, the paper assumes that ATM future will above all depend upon changes in the supply chain design of service provision, in other words on the dynamics of vertical relations between air navigation service providers (ANSPs), equipment suppliers, airline companies.

From that perspective, the paper addresses three key issues:

- Why has the current ATM supply chain reached its limits and why is this kind of organizational design probably unable to cope with future technological changes?
- What kind of evolutionary strategies are developing in the sector (vertical downstream and upstream alliances, vertical downstream and upstream integration, setting up of vertical businesses, buying off the shelf)?
- How can the revolutionary strategy developed by Boeing be analyzed and assessed? Could this strategy spark a major change in air traffic management service provision in the future?

1. Introduction

From the mid-eighties, air traffic management (ATM) has been in crisis: congested sky, flight delays. It is likely that the diminution of air traffic consecutive to the 9/11 will only be temporary. Economic growth and demography will lead to a new trend of traffic growth in a few years. The tension in the system will then reappear. The situation is more or less comparable in Europe and in the U.S.

Usually, technology is considered as the solution to the issues of the ATM future. The problems encountered nowadays are supposed to be solved, in a long term future, by datalink between aircraft and ground, positioning by satellites, and other technological discoveries. The short term looks gloomy. Technology will solve the issue in the long term. This is quite a paradox: ATM is precisely a field where technological failures have been numerous and huge in the past (collapsus of AAS in the US, major delays in other projects - NERC, WAAS, etc.). Aircraft are still guided by controllers using a screen, radars, small strip bands, and old radiocommunication systems. As a system, the technology used in ATM seems to be, basically, the same as the one used in the sixties, although improvements have occurred (Marburger, 2001).

The perspective suggested in this paper is different. The basic assumption is that technology does not spontaneously develop, does not solve problems in itself. Therefore, to try to highlight the future of ATM, focus must be put on industrial organization and strategies. Who will pay for what? Who will lead and support the technological shifts? Which kind of technological strategies can be developed, by what kind of players? Which kinds of resistance can oppose these shifts? These questions raise critical issues and this paper aims at addressing them.

First step we consider ATM service and infrastructure as a whole. This service is currently organized through a certain form of supply chain: state-owned service providers buy systems (radar stations, navaid stations, control centers, communication systems) from equipment suppliers. Then, the question arises: can this supply chain evolve? Is it beginning to evolve because of corporatization, and in what directions? How do incumbent and new players use technological shifts to try to modify the supply chain in order to capture a larger part of the value? Is vertical integration a valuable strategy? Who is going to integrate, downstream or upstream, and using what sort of integration?

The approach has mixed the use of a theoretical perspective (the supply chain approach, supply chain referring here not to logistics – the narrow sense-, but the whole chain of capabilities necessary for a service to be supplied to the customer – a much broader sense – see: Fine, 1998; Dumez, 2002; Rice, 2002), analysis of documents and interviews with people involved in the chain.

Although the dynamic of the ATM supply chain cannot be predicted with accuracy, the ATM future cannot be thought of independently from scenarii of future supply chain design.

2. Economic perspective on the ATM service

The economic perspective applies to the supply of the service itself and to equipment supply.

2.1 ATM service provision

International rules set up by the International Civil Aviation Organization (ICAO) prevent the transformation of the ATM service into a real market. A state is not authorized to raise money in selling the access to its sky. It can only ask airlines to pay for the service given to their aircraft passing through its sky: communication, surveillance, navigation, airspace design, control, flow management. In Europe, the total amount of en-route charges came to 4,340 billion euros in 2000 and 4,436 billion of euros in 2001 (see annual reports of the CRCO), covering the total ATM service cost for Europe. In the US, the cost of ATM is paid by the passenger as a tax on his/her ticket. If a technological change (satellites, datalink, software) raises the total cost of ATM service, the market will automatically be inflated with this increase in cost.

If the control were to be given up by governments, and even if profits were strictly limited by ICAO rules, ATM service could become a rather interesting quasi-market for private companies, and more especially if a big costly technological change occurs.

A move has been made recently in that direction by the British government. The British Air Navigation Service Provider (ANSP), the NATS, has been corporatized and partly privatized (British government retains 49% of the capital, a group of airlines 46%, 5% being owned by the staff). A price-cap regulation has been set up, and the NATS is authorized to earn profits if it improves its efficiency[1].

2.2 ATM equipment industry

To be able to deliver the service, ANSP have to be equipped. The service requires radars to determine the position of the aircraft, navaid stations to help aircraft knowing exactly where they are, communication systems to secure exchanges between controllers and pilots, computer-based systems to help controllers to detect potential collisions, combining computerized data coming from flight plans (flight data processing) and data coming from the radar source.

Technology could change in the future, and certainly will. Exchanges between controllers and pilots could be partly automated (if aircraft are equipped with datalink) and managed by satellites. Aircraft could be positioned by satellites instead of ground navaid stations. However, today equipment is still as described above paragraph.

A small market

The ATM equipment market can be considered as small. Here, « small » has three different meanings.

[1] In 2001-2002, consequently to the 9/11, the NATS has experienced a rather bad financial situation and has asked its regulator for a price increase.

First, the whole worldwide ATM market is estimated at about 3,5 billion dollars or euros. Compared with other markets in which incumbents firms are involved, it is a small market. For example, ATM sales represent only 4% of the total amount of Thales sales, Thales ranking second in the world ATM industry.

Secondly, the market is small in another sense. The restructuring of the industry has not been done from an ATM perspective: it has been « residual », a consequence of the restructuring in the defense and aeronautics industry. Raytheon and Hughes have merged for defense reasons. Lockheed had the project to merge with Northrop-Grumman, but the merger was prohibited in 1997 by the Clinton administration for antitrust concerns on the defense market (Markusen and Costigan, 1999). In other words, the market is « small » in the sense that market restructuring is not driven by considerations directly related to the market itself, but by external considerations (defense and aeronautics).

Finally, the market is small because incumbent system integrators are few, and because everybody in the market knows everybody. The incumbent system integrators are Alenia-Marconi, Northrop-Grumman, Lockheed-Martin, Raytheon and Thales, the last three being by far the biggest ones. A lot of other firms hold niches: more significant examples are Indra for flight data processing, Litton-Denro in the communication market for ATC (acquired by Northrop-Grummann in early 2001) or Frequentis. For such a small market, one can think that the number of the players is still too high. If Lockheed had been authorized to merge with Northrop-Grumman, a small player would have exited.

A fragmented market

Until recent years, the market has been organized on a national geographical basis, with two segments. As each state is responsible for its own airspace (Chicago Convention, 1944), ATM service has been provided for by national state organizations. Each country has set up its own control centers, hired its own controllers, bought its own ground equipment (radars, navaid aid stations, communication systems). This is true of the United States (which probably counts for 40-45% of the world global market) as for Switzerland. National industrial policy considerations have played a significant role in the market: it is as difficult for a genuine American firm to sell equipment in Europe, as it is for a genuine European firm to sell in the United States. As the supply side needs to be restructured (see above), there are big opportunities of economies of scale and economies of scope in this market in the restructuring of demand side.

The market is segmented in two parts.

The first one is made of non yet experienced countries, having no technical skills and teams. A software developed for another country can be sold to them with a few changes about 5% of the software). It is a – if not yet completely standardized- « standardizing » market.

The second one is made of sophisticated large or middle-size countries, like the U.S., France or the U-K. The French service provider has its own technical teams (several hundred of people) able to develop internally the systems required in its own control centers. France is the extreme case, but other large countries have internal technical skills. This group of countries ask for specific sophisticated systems. Of course, the most complex airspace portions are found in these countries (London, Chicago, and so on). But one can also ask if there has not been in the past a tendency towards hypersophistication in these countries: it is doubtful whether controllers always use in practice all the functions offered by the installed systems.

2.3 The nature of ATM service: a routing industry facing the challenge of customization

What kind of service is ATM?

It is what Lampel and Mintzberg call a « routing industry. » These industries « […] accept their customers' orders in purely generic ways but then route them completely individually, in processes that are fixed and inflexible. » (Lampel & Mintzberg, 1996: 28). Transactions between the service provider and the user are standardized: airline companies pass on their flight plans, and the service providers organize themselves to route the different flights. The process is highly standardized: aircraft follow routes, are under supervision, are given orders, by means of technical systems and safety rules. As each flight is unique, the service can be called « customized ». But, Lampel and Mintzberg note that these industries are now evolving to a even more customized approach. The general approach, so far, has been technical and undifferentiated: the first in, the first out. Nowadays, these industries are engaged in a trend to better take into account the users' wishes or business constraints. Clients can have priority rules that differ from the first in/first out rule. It is already the case for cargo companies. During the day, Louisville Kentucky airport, is shared by airline companies. At night, it is only run by UPS, as a hub. UPS specializes in express mail and parcels. Between 11:30 PM and 2 AM, aircraft come from everywhere in the US and the world. Early in the morning, between 4 and 6 AM, aircraft take off for all over the world. UPS knows exactly what the situation of its fleet is, what parcels – and, consequently what flights – have priority (in case of delay, UPS has to reimburse the client). It can be essential for UPS to ask the terminal control center to delay one flight arriving in advance to let land in priority another flight already delayed, which means departing from the first in/first out rule. This can be done quite easily, because at night UPS is the unique company using the Louisville airport facilities, and every aircraft arriving and leaving belongs to UPS. But this kind of situation may develop in every hub. ATM service providers are under pressure from the airline companies to take their business constraints into account. As the demand for traffic grows and as the service provision hardly faces this growth, the pressure is higher and higher: big companies are willing to pay a higher price for a better, more customized, service. This raises a conflict between business constraints pressure and the high degree of process standardization due to engineering-based rules. Customization would mean increased flexibility and reactiveness of the system to the expectations of pilots and airline companies.

3. The traditional way of delivering the service and its limits

For years, ATM service provision has been delivered by public administrations. In each country, the Department of Transport (and/or the Department of Defense) has a specialized branch in charge of air navigation services. This branch owned and operated air traffic control centers.

Stakeholders, airline companies in the first place, were consulted, kept informed, but did not take part in the decision-making process. Investment plans were decided in the public sphere (executive and legislative branch of the government).

An analysis of the U.S. case illustrates the kinds of failures the ATM traditional service provision produced.

The difficulty to carry out big technological projects

The FAA has tried to improve its technological tools in functional areas – communications, navigation and landing, and weather. Equipment in these areas have been deployed « with major delays » and « have continued to experience numerous technical problems. » (G.A.O., 2001, may,: 11).

« [An] equipment in terminal facilities has encountered major cost, schedule, and performance problems. As a result, as FAA has not established a new schedule to deploy this equipment – the Standard Terminal Automation Replacement System (STARS) – it has indicated that the project's development cost will increase by nearly $500 million over its original 1994 estimate of $940 million. » (G.A.O., 2001, may: 9).

In the ATM industry, history of investment in new technology is paved with this kind of delay and increase in costs. « ATC modernization, which was announced in 1981 as a 10-year, $12 billion program, has expanded and is now expected to cost more than $44 billion through fiscal year 2005. » (G.A.O., 2001 May: 6).

The difficulty to integrate various technological projects

ATM requires the integration of many technologies in different fields: communication, navigation, surveillance, software and hardware. Projects in these fields have different « clockspeed » to use Fine's word (Fine, 1998). The efficiency of technological change depends on the match between these different clockspeeds: if one technology changes faster than another, there can be no efficiency gain at all. « [Challenges] include integrating the technologies with each other and other ATC systems to achieve the synergies anticipated (…). » (G.A.O., 2001, may: 2).

The difficulty to change human practice at pace with the technological change

To improve fluidity of traffic, new technologies will let the aircraft be « freer » to choose their own routes, and to maintain safety rules jointly with other aircraft. This « will change the roles and responsibilities of controllers – necessitating a major cultural change. » (G.A.O., 2001 May: 10). At the moment, controllers separate traffic according to distance and they will rely more on automated technology to separate traffic according to time. « Under the newer method of separating traffic, computers will help controllers balance the arrival flow into terminal airspace by assigning a certain time for an aircraft to reach a predetermined point. » (idem). G.A.O. notes: « FAA acknowledges that transitioning to the new method will take time , but has yet to develop a strategy, including detailed training, to help ensure its success. » (idem).

The difficulty to design a new institutional framework for sharing the costs and benefits of technology change

More and more, technological change modifies the balance between aircraft-embarked equipment and ground equipment. Ground equipment is traditionally paid by taxes or en-route charges. Aircraft-embarked equipment has to be paid by airlines, business and general aviation. The efficiency of the whole system requires that all aircraft, all ATM systems, be equipped. FAA has defined its own investment planning in its Operational Evolution Plan (O.E.P.) published in may 2001. « The full cost of the OEP is unknown. FAA estimates that over the period of 2001 to 2010, its portion of the cost will be about $88.5 billion (…) Other significant funding will need to come from airlines and airports. For example, before benefits

of new air traffic control technology can be fully realized, aircraft must receive new equipment. As the recent economic slowdown and the terrorist attacks have shown, the airline industry is subject to periods of profit and loss. If new equipment comes on-line at a time when airlines think they cannot afford to buy it, the planned benefit may not materialize. » (G.A.O., 2001 December: 15).

We have chosen to focus on the U.S. case and to rely on the analysis made by the General Accounting Office. But we could have chosen other cases: France and the PHIDIAS project, United Kingdom and the New-En-Route Center (NERC) project (House of Commons, 1998), or others. We would have encountered exactly the same difficulties: delays and cost increases in managing technological projects; difficulty to integrate systems of new technologies; difficulty in facing the evolution of the role of controllers, due to new technology; difficulty to redesign the institutional framework to answer the question: Who will pay for what?

The traditional way of delivering the service has reached its limits for many years now. Despite past failures, it is trying to face the future change. Since 1998/99, the FAA has made an effort to associate airlines with its projects. The FAA wanted to be sure that airlines would invest in embarked-equipment at pace with its ground investment. This approach has led to its ten year plan, the Operational Evolution Plan (O.E.P.). In addition, the FAA has announced it will become a « performance based organization ». But a lot of people wonder whether the traditional way of doing things, which has so often failed in the past, is able to succeed in the future. In the past, "while the relationship between the FAA and NASA has been good at the research level, there is not a good process for the requirements to flow down from the operational elements of the FAA." (Hansman, 2001). The Bush Administration has declared it was considering the transformation of the FAA, its corporatization.

4. The evolutionary strategies

Many countries have now corporatized their air traffic services providers, which are now « autonomous authorities » in the sense of International Civil Aviation organization (ICAO). This means that these ATM service providers are not private companies doing profit, but, in general, independent non-profit organizations. They are able to:

- keep their books in accordance with Generally Accepted Accounting Principles (GAAP);
- be governed by a corporate-type board of directors;
- borrow from the private capital market;
- support themselves via fees charged to users" (Poole & Butler, 2001).

They can also develop new vertical relationships with suppliers and clients, modify what the arc of integration (Frolich & Westbrook, 2001) and that is the point we will focus on in the following pages.

4.1 The downstream quasi-integration

The ATM service is provided to airlines. In the past, the decision-making process has failed to take into account the strategy (the hubs and spokes strategy, for example) and the interests of airlines. Airlines are the main stakeholders of the service and the control on investment and cost could be better managed if airlines were associated with the decision-making.

One option is vertical integration through a user club arrangement: in this case, airlines become main shareholders of the ATS provider. The United Kingdom can be singled out as an example with the Airline Group owning 49% share of NATS (Goodliffe, 2002). However the option requires the downstream market to have sufficient financial strength. But since deregulation airline companies are struggling for profitability.

The other option is downstream quasi-vertical integration: this means that the airlines would not own the stock of the ATS provider, but that they would substantially influence the decision-making process (fees, investment, etc.), being represented in a supervisory board or a board of directors, as in the NAVCAN (navigation services Canada) model. Usually, corporatization of the ANSP has come along with this kind of downstream quasi-vertical integration.

The downstream quasi-vertical integration, although it is developing through the growing corporatization process of ATM services, will probably not represent a major shift in ATM future. Airline companies only aim at monitoring investment in order for it to be at pace with the growth of the demand and to reduce delays and at keeping cost at the lowest possible level. ATM service is not core competence of airline companies, nor is it a potential profitable business. This shift in the supply chain does not seem central.

4.2 The upstream quasi-vertical integration

Upstream quasi-vertical integration means intensified relationships between ATS providers and equipment manufacturers. At the moment, this strategy is only emerging. But corporatization has made it possible, and this feature can develop in the future, especially because of the diminishing part of public funding in ATM. The quasi-integration will probably be gradual: beginning with ancillary services, going on with core equipment (software), and maybe reaching the service itself.

The possible scenarii

The first step could be the maintenance. Until now, the ATS providers have bought the software system from equipment suppliers. ATS providers prefer to put the systems into service by themselves. According to the system supply contract, the suppliers give assistance to them for generally two or three years. Then, ATS providers ensure the maintenance. This is an important part of the total cost service provision and this division of labor is far from optimal. Maintenance could well be the first part of the service to be outsourced.

The second step would be the outsourcing of ground equipment. Radar stations, navaid stations, communication systems require a huge amount of investment to be modernized. It is doubtful whether this investment could be funded by public money. A solution could be to raise private money bet against a transfer of property. As many equipment manufacturers have as a traditional core competence in radar manufacturing (Northrop-Grumman, Raytheon, Thales), they can be interested in this transfer of property. The equipment would be rented by ATS providers.

The same approach – third step - could be applied to the control infrastructure. A state can decide to organize a tender for ATC centers. The controllers, the control itself, would remain a government job, but the equipment would be rented from an equipment supplier. This solution could have been the UK one for the Scottish ATC center before the British government finally chose to privatize the NATS.

The last step would be the outsourcing of the control itself. This would raise important safety issues. This solution has been chosen by Emirates, which have outsourced the control to a British firm, SERCO.

The first moves

Some new strategies have been developing on the market.

The buying off the shelf

Public financing of ATM investment is decreasing. Countries can hardly develop a system exactly adapted to their specifications. Buying off the shelf seems to be a solution.

This solution can be backed by a coordination process on the demand side. This is what CANSO tries to set into motion. CANSO is a non-profit association of corporatized ANSPs. In early 2002, CANSO has set up a joint procurement workgroup in order to increase efficiency in procurement. If several ANSPs agree about common standards, develop a joint buying power, and buy off shelf, purchasing costs will decrease.

On the supply side, a system developed for one ANSP can be sold thereafter to other ATS providers adapting it to each configuration with minor changes. As a system is not only a technical equipment, but also a set of procedures and a complex way of implementing the system, the sale often implies both the equipment supplier and the service provider for whom the system has been developed. More and more frequently, ATS providers ask for intellectual property rights on the system developed for them. Consequently, they have an incentive to help equipment suppliers to sell the system to other providers. Economies of scale captured by the selling of the same system to many service providers can drive a decrease in ATM costs.

Thales ATM, for example, has developed and improved an ATM system, Eurocat, which has been adopted and completed by Airservices Australia with Thales ATM as a prime contractor (TAAATS - The Australian Advanced Air Traffic System). This system has been sold to China for an amount of 100 million euros and will equip En-Route centers in Beijing, Shangaï and Guangzhou, three approach centers and four control towers. Chinese controllers will be trained in Australia.

This joint interest in selling systems developed by an ATS provider with an equipment supplier can lead to tighter relations between both partners.

The vertical alliance

The New Zealand ATS provider, Airways, has been corporatized in 1987 and is now a state-owned Enterprise. In 2001, Lockheed-Martin ATM and Airways have signed a 10-year partnership agreement to modernize New Zealand domestic air traffic management system and to create in Christchurch, New Zealand, a software development and operational testing center.

This partnership is presented by Lockheed as a new business model. Lockheed-Martin ATM president, Don Antonucci, has declared: "Within 10 years, we expect air traffic management to be provided on a global basis by four to six alliances. With this agreement, we will be an integral part of one of those alliances, providing seamless, efficient air traffic management to airline customers around the world."

The strength of this kind of vertical alliance has been stressed by Craig Sinclair, chief executive of Airways: "A fundamental problem in this industry is the failure to deliver complex systems on time and to specification. And uniquely in this industry, it is the customers, not the shareholders, who pay the cost of that. We need to combine technology strengths with service delivery and that means technology providers should work with service providers to create a commercial platform that will allow us to meet customer needs […] Technology is the enabler, but air traffic services must be run like a business: this partnership combines both those strengths, and in future we will find that there will be so much value created by alliances that alliance partners will simply be able to discard a particular technology solution if it does not fit."

Skyline system, jointly developed by Airways and Lockheed Martin, has been sold to China (10 million dollars). Airways will customize the system on behalf of Lockheed-Martin to meet the specifications ordered by China with work being carried out at the Christchurch Center and Chinese controllers being trained in New Zealand.

The vertical alliance model is supposed to be the first step of a large-scale restructuring of ATM: the vertical alliance between an equipment supplier and one ATS provider is the basis of further alliances with other service providers. If these ATS providers handle the traffic in the same part of the world, they can close centers, develop others, share the business in a « seamless and efficient » way, to quote Don Antonucci (see above). The same kind of alliances will occur in other parts of the world, and ATM will be, at the end of the process, managed by « four to six » alliances, according to LMATM CEO.

The extension of the scale of the business has been projected by the Airways/Lockheed-Martin alliance since the team, with ADACEL Technologies (provider of New Zealand's existing Oceanic system), decided in 1999 to bid for the US FAA Oceanic system replacement. In june 2001 the FAA awarded a $217 million contract to the Lockheed-Martin team.

The vertical integration

A step further could be vertical integration, the buying out of an ATS provider by an equipment manufacturer. This solution has been tried, but has not been carried through. When the British government decided to privatize its ATS provider, the NATS, Lockheed-Martin was one of the bidders. Lockheed-Martin is the main equipment provider for the New En-Route Center (NERC) of the NATS. Finally, a group of airlines was chosen. But the bid by Lockheed-Martin illustrates the fact that an equipment supplier can have an interest in integrating downstream in service provision.

This interest depends on the opportunities to extend the business. This would involve selling the same global solutions to other service providers or trying to extend in surrounding airspace, for example the Oceanic areas.

Creating the business

In some regions of the world, there are no ground stations, either radar nor navaid ones. That is the case over the oceans or the poles. As the old technology does not exist, the transition to the new one can be more easily proposed and tested. As ATM systems are embryonic in these areas, every solution, no matter which one, has a good chance to improve the situation.

During the cold war, the Russian area of the North pole was filled by naval bases, missiles sites and nuclear early warning stations. These zones were forbidden to foreign airlines. It took 21 hours for an aircraft to fly from New York to Hong Kong. If the same aircraft were authorized to fly over the North pole part of Russia, the same flight would only take 15 hours and a half. Russia has realized that an en-route charge per aircraft could allow the country to earn $700 million a year that could be invested in air traffic systems. British Airways, with the help of Boeing, has worked with Russian authorities to introduce a new satellite air traffic control system, FANSTAR.

Another example is provided by the contract signed in March 1997 between Raytheon and the Mongolian Civil Aviation Authority. Mongolia needed to improve its ATC system at Ulan Bator airport and on its whole national airspace. To finance this investment, a first step was to improve safety for overflights through surveillance and to bill for this service. Raytheon installed an AUTOTRAC control center system integrating automatic dependent surveillance (ADS) and controller to pilot data link communication (CPDLC). The system simultaneously provides location, identification, altitude, speed and direction information to all equipped aircraft and to the ground center. It is able to manage equipped and non-equipped aircraft in the same airspace. Northrop-Grumman has been trying this kind of model in Georgia in the late 1990s.

Other bidders for the Mongolian procurement were Italian, French, but also Indian (GCEL/ECIL) and Japanese (Itochu Corp., Marubeni Corp. and Sumitomo Corp.).

This strategy consists for an equipment supplier in helping an ATS provider to create a business linking the safety issues brought about by a growing traffic and the economic issues – covering the cost of the development of the ATM system through charging aircraft flying over.

4.3 Assessment of evolutionary strategies

Evolutionary strategies concerning the supply chain are twofold: customization intensifying downstream relationships (customization) and intensifying upstream relationships (partnerships between equipment suppliers and ATS providers).

Customization is a general trend and aims at avoiding failures of the past: big new technological systems never implemented and increasing delays and problems in air traffic management.

Upstream strategies - exploiting economies of scale, alliances, attempts to vertically integrate, creation of new businesses - aim at bypassing the current fragmentation of ATM systems. Regroupings are expected in Africa, Europe (Single Sky initiative, CEATS in central Europe, NUAC in Scandinavian countries), Latin America and in the Asian/Pacific area.

Customization is a general trend in ATM but has not led to major changes. Upstream vertical strategies have not yet affected the major congested ATM systems, the US and Europe. They remain peripheral: they have helped to create new ATM systems, they have occurred in non-congested areas, they aim at improving Oceanic or North Pole traffic. A band-wagon effect is expected, but remains dubious (Golaszewski, 2002). In the US and in Europe, the same players (national state owned ATS providers play the same game they have been playing for dozens of years: they plan big investments arguing that they will succeed this time even if they have failed in the past. They say that ATM systems, as complex technological systems focused on safety, show and must show a high degree of inertia. Controllers keep

on following aircraft through screen images given by radars on limited sectors, and speaking to pilots through VHF channels. That is the reason why new players try to develop a different approach, a revolutionary one.

5. The revolutionary strategy

The revolutionary approach relies on many arguments. Old technologies have reached their limits and will not allow the system to develop in pace with demand. Restructuring drags on: there are still 21 en-route centers in the U.S. and 58 in Europe, while one center can be technically sufficient (or two, for security matters more than for technical efficiency); the situation is even worse in Europe. The system is unable to adapt to the speed of the growing demand. « The status quo is the only solution that must be vetoed » (Hayhurst, 2002). New technologies have been developed for years and some of them are already in use in different industries: satellite positioning, communication by satellite, datalink between ground and aircraft computer-based, decision-making systems. The problem is to integrate them and the old business structure is unable to carry out this integration. Something really new must happen: a revolutionary approach has to be adopted. This approach can hardly be developed by incumbent players: only an in/outsider (insider as technical competence in ATM matters is required; outsider as a completely different vision from that of incumbents must be developed) can do the job.

There have been attempts to develop a revolutionary strategy in the past. These attempts are an interesting point of reference for Boeing's strategy.

5.1 A precursory revolutionary strategy

In 1994, the European ATM system faced congestion and the French corporation Aerospatiale considered that, having a great experience of what data are handled in the aircraft cockpits (Aerospatiale is one of the main constituents of the Airbus group), being a manufacturer of satellites, and being the architect of the air defense system and of the French nuclear defense system (surveillance and guidance of missiles, management of complex communication exchanges between aircraft, submarines, ground missile sites, military and political decision-makers), was in a good position to take responsibility for leading the change.

Aerospatiale built up a team of 30 system engineers and tried to be the « industrial architect » of the system, in a "system of systems" approach.

As explained on a slide of that time, « An industrial architect is:

- Independent from equipment manufacturer
- taking care of each requirement at the same level
- aware of technology and industrial capability
- providing a complete and coherent solution

and is « a guaranty for a cost effective ATM implementation. »

In 1998, Aerospatiale decided to put an end to the attempt. The problems the team had to face were mostly political and managerial: Aerospatiale was not seen by Raytheon or Thomson (now Thales) as an « independent from equipment manufacturer » as proclaimed in the slide, but as a competitor; Aerospatiale did not haul the political power to bring together all the parties involved in ATM: airlines, controllers, pilots, airports, aircraft

manufacturers, equipment suppliers, ATS providers. In addition, no customer was ready to consider a "system of systems" approach: there was no market for Aerospatiale to sell in skills.

A few years after, Boeing returned to the task of system architect, with some winning cards in its hands that Aerospatiale was missing: among them, major political power and a managerial tool, the Working Together Team.

5.2 Boeing revolutionary strategy

Boeing explicitly presents its strategy as a revolutionary one. As we will see, the meaning of this is not completely clear-cut.

Boeing's position in the chain

Boeing has two main characteristics in the chain.

It has a major political power in the U.S. Boeing's CEO has direct access to the Department of Transport, the Department of Defense, and even the White House. It has both civil and military businesses. Boeing has a direct relationship to airlines. But Boeing is also a big international player: 75% of Boeing aircraft are sold outside the U.S. Boeing has not only a national view, but also an international one. Its voice is listened to in Europe or in Asia, as it is in the U.S.

From an economic perspective, Boeing's bigness has a double impact. Boeing (with a revenue of $51.3 billion in 2000, $31.2 for its commercial airplane business alone) is too big to be a competitor to equipment suppliers: even if Boeing took the whole worldwide market of ATM equipment, this would be only 10% of Boeing's aircraft sales. At the same time, Boeing's financial power plays the role of a « big stick » in the market: Boeing has the economic power to develop strategies in the ATM market, to test new ideas or equipment. Boeing has set up in November 2000 an ATM subsidiary which had, less than two years in existence, a 250 staffing. This gives an idea of Boeing's investment in the ATM business.

Boeing's strategy

Officially, the strategy is twofold, as John Hayhurst, CEO of Boeing ATM, presented it before the Commission on the Future of the United States Aerospace Industry: « Boeing is in the process of orienting the company toward providing a wider array of services to our customers than we presently do. We also recognize that our core business, building and selling large commercial aircraft, must continue to grow and be healthy. To accomplish this, with its attendant jobs, exports, and overall economic impact, it is crucial that the aviation system be able to accommodate anticipated growth. » (Hayhurst, 2001). Boeing has a vested interest in keeping the ATM system efficient: future aircraft sales depend on traffic growth, and traffic growth can be checked if congestion remains at its present level or becomes worse.

Old concepts integrated in a « holistic approach »

On the Boeing website, a document can be loaded which is entitled: « Air Traffic Management. Revolutionary concepts that enable air traffic growth while cutting delays. » This title is universally believed to be misleading: actually, Boeing's concepts are not really new, and are far from being revolutionary. Three features define Boeing's approach (Boeing, 2001):

- Aircraft trajectory. This look-ahead capability provides air traffic managers with a 4-dimensional depiction of aircraft location now and where it will be, further into the future and with more precision than ever before.
- Common Information Network. Data integrated by this new network will synthesize a much more comprehensive, accurate picture of the entire airspace system than has been possible to date.
- Redesigned airspace. By leveraging new capabilities in visualization, planning and communication, it is possible to simplify airspace structure and create new air traffic procedures for less tactical intervention, more strategic planning. »

These different features are not new, but the "holistic", global, approach is. The aim is to build up « a system where the position and intent of every airplane in the system are known. Where guidance is strategic, not tactical. Where there is one global system, not hundreds of separate systems. Where information is shared so seamlessly that geographically dispersed authorities can instantly collaborate and rapidly respond to any situation. » (Hayhurst, 2002).

Boeing's new managerial tool: the Working Together Team (WTT)

In the early 90s, Boeing began to design a new jetliner for the first time in more than 12 years. The first step was to set up a Working Together Team. The core concept behind a WTT is to gather a wide range of input on the needed capabilities of a new system from the various groups who will use the system. A collaborative process allows for heightened communication and involvement of all stakeholder groups. Then, the WTT was used as a platform to help design, integrate and test the 3 million parts of the plane that must be proven safe before the first delivery (Benson, 1994).

In November 2000, Boeing set up its ATM subsidiary. On 6 June 2001, when the FAA published its Operational Evolution Plan, the team published Boeing's concepts (Boeing, 2001). In July, ATS providers, commercial carriers, military, general aviation, equipment suppliers joined the WTT created by Boeing. The group began to work on the system requirements: what are stakeholders' expectations regarding the future system? A first document was released at the end of February 2002. The group goes on to try to define system requirements and begins to elaborate on operational concepts and schedule. Boeing has enlarged the group in inviting Eurocontrol to join. It is now a truly international, global, initiative.

Even if the first result was not a complete success - the draft of system requirements -, the WTT was probably the first time all the stakeholders were meeting to discuss ATM future. Many of them are still skeptical, but they were all impressed by Boeing's commitment.

Boeing's strategic moves

In a sense, Boeing seems to be an outsider. But Boeing is involved in ATM as it has had to figure out how to equip the cockpits of the aircraft it builds. Boeing has also accomplished a series of strategic moves directly connected with ATM.

First of all, Boeing has become the world's largest satellite manufacturer through the purchase of Hughes Space and Communication Division. In 1997, Boeing applied to the FCC (Federal Communication Commission) for a license to use the 2GHz Mobile Satellite Services (MSS) portion of the spectrum. This is an important point, because, to work effectively, Boeing's ATM system needs a sufficient amount of dedicated radio spectrum. After four years of a collaborative effort with the FCC, on July 18 2001, Boeing finally got the

license to build a medium earth orbit constellation of non-geosynchronous orbit satellites operating in the 2 GHz band. One Boeing official declared: "This exciting new development adds further credibility and momentum to our project and is an important step for the WWT team of stakeholders to further define the system."

Boeing has also recently purchased two players of the supply chain: Jeppesen, the premier aeronautical charting company, and, still much more important, the Preston Group, the world's leading airspace modeling company. Preston Group provides Boeing with a very powerful tool: since its acquisition, Boeing enjoys a monopoly power on advanced simulation of airspace.

Boeing ATM has also begun to bid for appropriation procurements, on its own or as a subcontractor of other players in the supply chain. In February 2002, the Department of Defense Appropriations Bill for 2002 earmarked $27 million for Boeing's global satellite-based communications, navigation, and surveillance architecture. One month later, Boeing ATM joined the Lockheed-Martin team in competing for the En-Route Automation Modernization (ERAM) program announced by the FAA.

Boeing's political strategy

Boeing has developed political strategies, trying to attract natural supporters in its revolutionary strategy: the NASA, in charge of the long term future of the airspace, the Department of Defense, Eurocontrol, the European institution in charge of thinking over of the future of the European airspace. Boeing has done its best to gain the other players of the chain good will: Lockheed-Martin in particular. At the political level, Boeing, aware that the launching of a constellation of satellites will cost a lost, upholds the project of « new public/private partnerships to reduce risks and speed implementation of new capacity enhancements. » (Hayhurst, 2001).

5.3 The assessment of the revolutionary strategy

As analyzed before, Boeing holds in its hands a series of winning cards no other player in the chain holds: its financial size, its political power (it seems that the Director of the Office of Science and Technology Policy, and President Bush's advisor for scientific matters, John Marburger, generally shares Boeing's vision – Marburger, 2001), its position in the supply chain, both internal and external, American and global, its competence in integrating complex systems of systems (large jetliners, but also International Space Station, GPS network).

How has Boeing's strategy been received and assessed? There is a consensus on Boeing's concepts: yes, technology is not the problem and can be implemented. Yes, voice communication raises a problem of capacity as a safety problem. Yes, the objective for the future is what Boeing says: today's air traffic management « is essentially a system of one-lane roads with policemen directing traffic on every corner. What we need for the future is an interstate highway system in the sky – a system that allows people to travel safely and securely without unnecessary aggravation and unpredictable delay. » (Hayhurst, 2002).

What is unclear for the different players is Boeing's aim. Is it only to disentangle a problem the different incumbents in the supply chain are unable to tackle for years, in order to be able to sell aircraft in the future? The size of the investment (250 people paid during many years at loss) seems not consistent with that argument put forward by Boeing. Is the strategy aiming at selling satellites? The different players think that it is not Boeing's major aim. Some say: Boeing has proposed a private/public partnership to cover the cost of the huge

investment in satellites; this means that Boeing has in mind the possibility of running the future system, maybe jointly with other players of the chain, against the billing of en-route charges. The ambiguity of Boeing's strategy, combined with its political and financial power, with its first strategic moves demonstrating its commitment, is a factor of major uncertainty in the chain, and is serving Boeing's aim: creating the conditions of a big change. Lockheed-Martin's first reaction to Boeing's announcement of its strategy has been significant: Don Antonucci, Lockheed-martin ATM's CEO, expressed a very skeptical view: he estimated the cost of the revolutionary project at $100 billion, « more money than I will ever be able to count in my life », he said. But, at the same time, he left open the prospect of working together again on Boeing's sweeping new proposal (Wait, 2001).

What is often stressed is the problem of transition (Hansman, 2001). The problem was identified by Boeing at the very early stage of its project: « One challenge to implementing a new system is the complex transition from today's system to a new operating paradigm. This transition must ensure safe, efficient operations 24 hours per day, 365 days per year. » (Hayhurst, 2001). But Boeing's approach, identifying three phases to manage the transition, was apparently not convincing. Nevertheless, a credible alternative to Boeing's strategy does not exist: among the incumbents of the supply chain, there is a consensus about the necessity of change, a consensus about the concepts and technologies to implement, and a consensus about the difficulty, even the impossibility, of the transition. Boeing is the only one to propose to disentangle the Gordian knot. The only alternative to its strategy is, as Boeing rightly says, some kind of status quo: let's try to succeed in what has so often failed in the past, and even if we succeed, anyway, it will not probably be sufficient to solve the future problems.

6. A strategy mix?

During the Farnborough air show, on July 22, 2002, EADS, Airbus and Thales announced the creation of the Air Traffic Alliance, linked with major initiatives by the European Union, Eurocontrol and European Civil Aviation Authorities.

According to the press release, the objective of this initiative is very close to Boeing's: the alliance partners propose a plan for simultaneous integration and deployment of aircraft capabilities with highly automated ground air traffic control systems fully exploiting the potential of new technologies enabling co-operation between aircraft and control centers.

The technology put forward is quite similar to Boeing's concepts: real-time exchange and sharing of dat, datalink air to air and air to ground, satellite based navigation, highly automated flight plan data processing.

The process seems to be similar to Boeing's Working Together Team: the Alliance intends to invite shortly other major European partners to join, and then to open a dialogue with North American players. The alliance is said to be "open", and having a clear objective to co-operate with airspace users, Air Traffic Services providers, and all stakeholders.

The approach differs from Boeing's on three points.

First, the strategy is not presented as explicitly revolutionary, although the time horizon is 2020, like Boeing's one. Nevertheless, a "unprecendeted move" is evoked, as if Boeing's strategy did not exist and as if this initiative was not a response to it. This probably refers to the fact that Boeing has no industrial skill in ATM.

Second, the Alliance's position in the supply chain is different from Boeing's one. Although described as "open", the alliance "brings together for the first time" a set of industrial capabilities at the different tiers of the chain: Airbus will contribute its airliner expertise, EADS its expertise in satellites and other aerospace technologies, and Thales its widespread experience in ATM systems and onboard electronics. Each participant of the Alliance will bring the skills of its core business to the Alliance. As far as one can analyze it, the Alliance is an up/upstream vertical alliance between an architect of systems (EADS), an aircraft manufacturer (Airbus, owned at 80% by EADS) and an ATM system supplier (Thales). Boeing's revolutionary strategy relies on a truly open architecture: Boeing has developped (as analyzed above) contractual links with Lockheed-Martin in the ERAM project, but this has been presented as occasional (although deliberate and important) and not as a vertical alliance. Boeing's strategical position is to be an architect, with a methodology (the WTT), and a critical power to give an impulse when needed. The ATM alliance is a vertical, quite global, alliance covering the different tiers of the supply chain, the ATS provision excepted. That is why the strategy of the Alliance is a strategy mix: revolutionary, as its aim is to do an "unprecedented move" in integrating new technologies, évolutionary as it is on line with an incumbent vertical strategy (Thales group's). On july 25, 2002, Alenia Marconi Systems announced that they had joined Thales to propose joint initiatives to the European Commission and Eurocontrol.

Third, the political situation in Europe is far more complex than the American one. John Hayhurst can say: "White House leadership will be critical to our success in this area, because the political issues involved are significant." (Hayhurst, 2002). There is no White house in Europe. The Alliance political power will not be Boeing's one. The political issue - critical in the ATM future - is not symetric on both sides of the Atlantic ocean.

Strategies are interactive. For Boeing, the creation of the Alliance is an indication: the sign that its own strategy becomes to be taken seriously by other players in the chain.

What can further strategic moves look like?

Other European players could join the "open" Alliance, which could try to become a European fortress for ATM future.

A symetric move in the U.S. could occurr, with the creation of a Boeing/Lockheed-Martin vertical alliance for example.

A transatlantic alliance between the European one, EADS/Thales and Boeing. Exactly at the time EADS and Thales announced the creation of the ATM Alliance, Boeing and EADS announced their intent to cooperate in the domain of the anti-missiles defense systems. There would be there a disiquilibrium, because of the EADS/Thales alliance. Therefore, Lockheed may join the transatlantic alliance. Other players would be reduced to being subcontractors.

A fight between the Boeing and the Alliance projects over a global -American/European - dominance, Boeing trying to enrol Thales American and European competitors in its poject and to contain the EADS/Thales Alliance.

7. General Conclusion: the future of ATM and the future of the supply chain

The evolution of the service provision supply chain will be one of the main drivers of the ATM future.

At the moment, two kinds of strategies have been launched in parallel: evolutionary ones, by incumbents, and a revolutionary one by Boeing.

The revolutionary strategy of Boeing will face a problem of dynamics and credibility in the next months. Many players of the supply chain have been interested by Boeing's discourse, impressed by Boeing's commitment and first strategic moves, but remain skeptical about the future developments of this strategy. If progress does not occur, the movement may run out of steam and skepticism will rapidly prevail.

Evolutionary strategies have the same kind of credibility problem, but on a much smaller scale. Will, for example, Lockheed-Martin/Airways alliance seduce other partners, or remain as a one shot trial?

In the debate between revolutionary and evolutionary strategies, the announcement of the adoption of a strategy mix by EADS and Thales will probably be an important step. Next strategic moves, which are bound to happen, will indicate the side the balance will turn.

For the ATM future, and from the supply chain perspective, a set of issues will also be critical.

The Bush administration has announced its intent to change the status of FAA. If the FAA, from far the major ATS provider in the world, becomes a more independent player, its appropriations policy will change (Cox, 1999). The entire supply chain will be modified, and Boeing's strategy could well find new ways of developing.

The European Single Sky initiative will also be critical. There are too many ATS providers in Europe, and too many ATC centers. This situation entails efficiency and probably (as the accident over the Bodensee shows) safety issues. European authorities are not in a position to redesign the supply chain. Nevertheless, they can be in a position to create the necessary conditions to a restructuring. In order to succeed, they have to think over the potential moves in the chain. From the accuracy of this reflection will depend the success of the initiative, or the failure.

The next months and years of the NATS, the British ATS provider, are to be carefully examined. The British government has been very far on the way of mixing private and public interests in the ATM industry. It has also chosen to turn down the upstream integration solution (the Lockheed-Martin bid) and to accept the downstream integration one (the Airlines Group bid). But the NATS is now in bad financial situation, while its shareholders are not in a better one. Many infer from that situation that the downstream integration is a dead-lock, even if customization of ATS provision must be intensified. If the public/private partnership is to be maintained, will the British government turn round towards upstream vertical integration? This would be a major change in the global supply chain of ATM: for the first time, an equipment supplier would control a large ATS provider. Or will the British government step back to a state-owned-company?

It is difficult to say at the moment how the supply chain of air traffic management will evolve. What is certain is the fact that ATM future cannot be understood in isolation from its supply chain future design.

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