2nd USA/EUROPE AIR TRAFFIC MANAGEMENT R&D SEMINAR Orlando,1st - 4th December 1998

# ATM performance review in Europe

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## Abstract

This paper examines the challenges facing the EUROCONTROL Organisation in improving the performance of air traffic management (ATM) in Europe. It mentions in particular the new performance review system established in 1998, whose role is to publish ATM performance indicators for the EUROCONTROL area, to propose performance targets and to develop economic regulation guidelines.

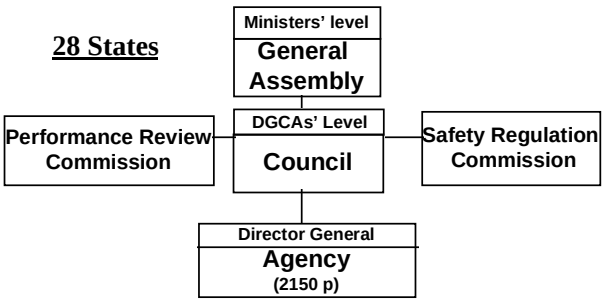
## Background

The EUROCONTROL Organisation is presently composed of 28 Member States in Europe, and of its permanent Agency. It is responsible for the provision of Air traffic services in its area. A number of initiatives were taken to meet the challenges associated with growing traffic as follows:

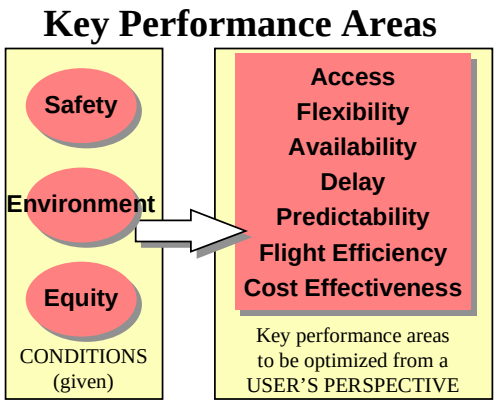
| | |
|---|---|
| 1988 | Centralized Flow Management(CFMU) |
| 1990 | ECAC Strategy for 90s, EATCHIP |
| 1992 | EATMS (Future ATM), APATSI (Airports) |
| 1994 | Prepare institutional Arrangements |
| 1997 | New Institutional Strategy<br>EUROCONTROL Revised Convention |
| 1999 | Strategy for the years 2000+ (ATM 2000+) |

Two main features of the new strategies are particularly worth mentioning here. First, they are performance oriented, rather than solutions oriented as was the ECAC Strategy for the 90s. Second, a compromise was adopted between two extreme institutional options, i.e. leaving each individual State responsible for its own ATM and having a single European ATM body: the provision of ATM remains decentralized, but a "strong, independent and transparent" authority, namely the Performance Review Commission (PRC), monitors ATM performance and set targets. This ATM system should be as efficient as if it was run centrally. The PRC reports at the level of Directors General of Civil Aviation, as shown below.

EUROCONTROL
institutional structure (simplified)




The PRC's task is to define and monitor Performance Indicators, to propose targets to be met by ATS providers and to publish guidelines for economic regulations, which could include incentives to meet those targets. The following picture shows the Key Performance Areas (KPAs) as tentatively defined.




In three key performance areas, called conditions, minimum levels of performance decided outside the PRC have to be met (safety, environment and equity). The ATM system performance is then to be optimized for the other KPAs from an airspace user's perspective. The first step is to measure the present performance and to understand where major deficiencies are. The next step is to understand trade-offs between performance items before targets are proposed. A further step will be to develop incentives for all players (users and providers) to behave in such a way that the system optimum is approached.

The relevance of this paper to the ATM '98 seminar should be clearer at this stage.

## The European challenge

### Traffic growth

Whilst the volume of controlled civil air traffic in Europe remained virtually static between 1975 and 1985, there was sustained growth of between 5 and 12 % per annum from 1985 onwards[1]. Despite competition from alternative means of transport and telecoms, experts widely predict sustained air traffic growth in Europe to accompany further European integration and the process of globalisation. In fact, more than half of the 200 main city pairs in Europe are still within the same country, and inter-country city-pairs are expected to develop.

[1] It should be noted that this date coincides with the signature of the Single Act introducing a Single Market in 1993, the impact of which was anticipated by users.

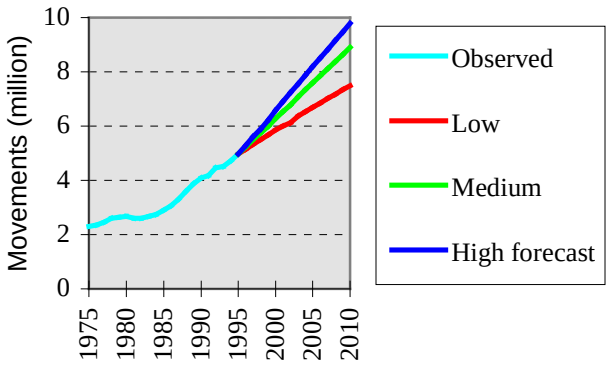



Figure 1: IFR Movements (Euro 88 area[2])

## ATM key performance areas

The performance of ATM must be improved, in particular as regards safety, delays, cost efficiency and other key performance areas (predictability, environmental sustainability, etc.) in order to respond to traffic growth and users' concerns. Corresponding potential benefits and savings amount to hundreds of millions of Euro[3] each year. The performance of ATM in Europe must be addressed at the continental level, since domestic airspaces are extremely interdependent[4], and the effectiveness of the network is largely dependent on its weakest link.

## Safety

Risk increases approximately as the square of traffic. If traffic doubles, the risk per flight hour has to be divided by four to keep the same absolute level of risk. In this context, it is essential to increase safety in order to guarantee public confidence in air transport. Safety does, however, come at a price, and a balance must be struck between safety and other forms of performance, such as the cost of the ATM system. Deciding between safety and performance does not fall within the remit of the PRC and should be carried out at political level (Council, Permanent Commission, European Union, etc.). The Safety Regulation Commission (SRC) and the PRC are deliberately separate. Performance review must take account of safety, but has no authority as regards the regulation thereof. A balance must therefore be found between both Commissions with regard to safety matters.

## Capacity and delays

The ATM system may be regarded as a network whose every node and arc has a limited capacity. When demand exceeds capacity in certain places, the most immediate solution is to manage the situation by holding aircraft on the ground. This reduces risk, cost (holding in the air is around 3.5 times more expensive than on the ground) and pollution, but does, however, generate ATFM delays which we have all no doubt suffered[5]. Flow management is therefore one of the solutions which was developed in response to the crisis at the end of the eighties. However, any imbalance between capacity and demand materializes in ATFM delays.

Since 1996, flow management has been run centrally by EUROCONTROL's Central Flow Management Unit (CFMU) on behalf of all the Participating States[6]. A "take-off slot is allocated to all flights passing through an overloaded area on a "first-planned, first-served" basis. Experience has shown that centralized, individual management of queues on the ground was more effective than decentralized management on the basis of origin-destination flows, as was the case previously. Furthermore, the high level of protection centralized management provides against random traffic peaks means that the acceptable traffic threshold can be raised in control centers. Delays on the ground imposed by the CFMU are the result of insufficient capacity at certain control centers and airports. In 1996, 15% of control centers were responsible for 90% of ATM-related delays. Furthermore, of some 800 airports capable of receiving commercial traffic in Europe, only a few of them (Heathrow, Milan, Athens in the summer, etc.) were responsible for the majority of delays attributable to insufficient airport capacity.

As with many queuing systems, the cumulated delays in the area has an explosive behavior as soon as the

[2] Source: EUROCONTROL/STATFOR. The "Euro 88" area comprises 11 States of Western Europe, i.e. approximately 75% of traffic in the ECAC area (most of the European States to the west of the CIS).
[3] 1 Euro is worth about 1.1 USD.
[4] 98% of European traffic departs from or lands in Europe, 74% of European air traffic is internal to the region, whereas a fraction remains within a single country (30% in the case of France, for example).
[5] It should be noted that there are many other reasons for delays, such as loading passengers/luggage, technical problems with the aircraft, insufficient runway capacity, unfavourable weather, etc.
[6] 33 in 1997.

demand/capacity ratio approaches one. Network capacity is difficult to determine with certainty, since there are alternative routes and the traffic structure changes, in particular between week days and weekends. System capacity is therefore shown as the relationship between demand and delays. An elasticity of the order of 5 has been measured between delays and demand, i.e. 1% extra demand increases delays by 5% with constant capacity and, inversely, 1% extra capacity reduces delays by approximately 5% with constant demand. An increase in capacity can be measured as that traffic increase which can be handled with delay remaining constant (+6,2% between 1996 and 1997). This is illustrated in the following graph.

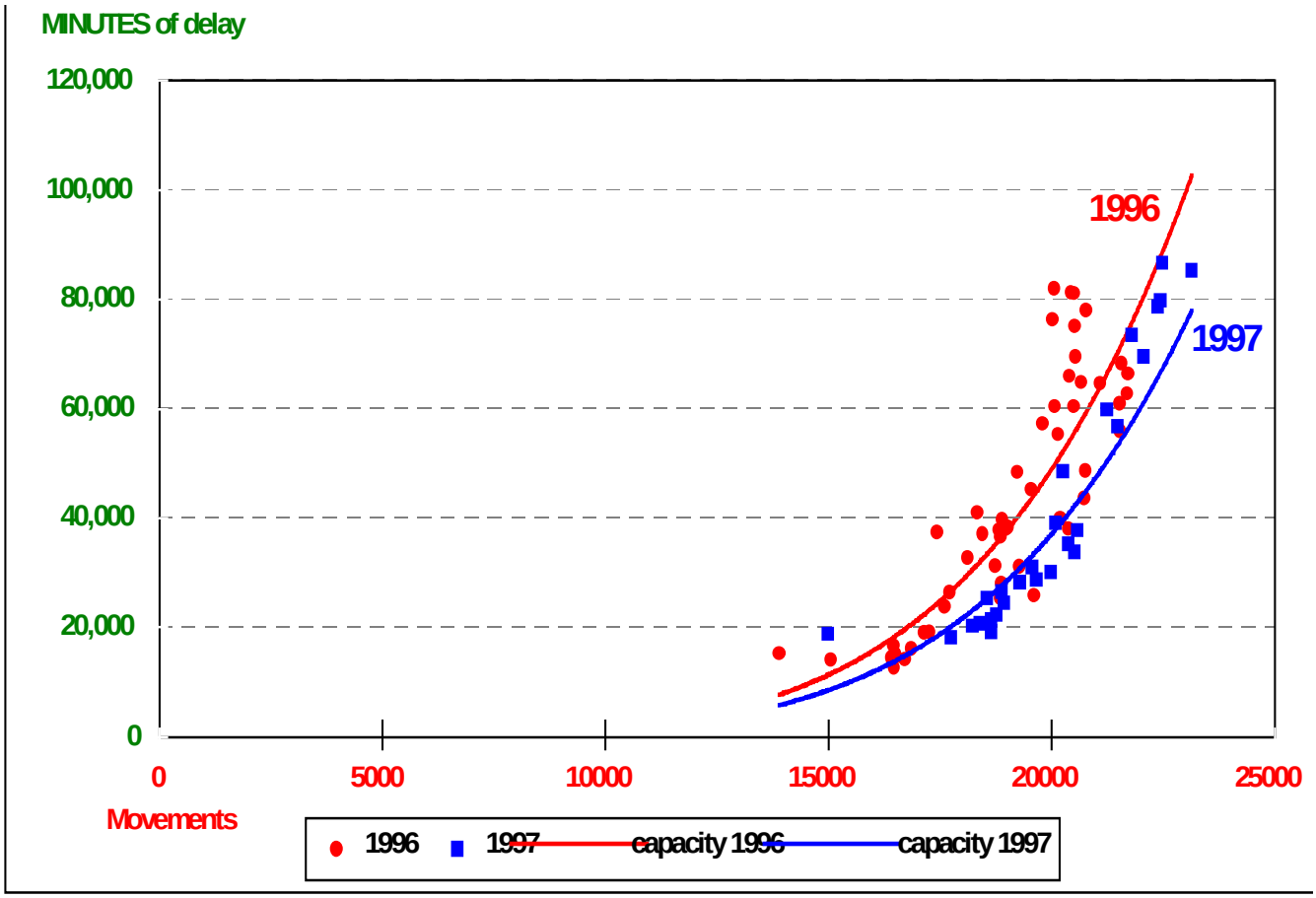



**Figure 2: ATM measured as the relationship between demand and delays**

Accumulated delays associated with insufficient ATM capacity in the CFMU area totaled 20.6 million minutes in 1996 for approximately 7 million flights, i.e. an average of 3 minutes' delay per flight. Around 20% of delays are ATM-related, and 7% exceed 15 minutes. The causes of the various delays are analyzed *inter alia* by the CFMU and EUROCONTROL's Central Office for Delay Analysis (CODA). The cost to operators of ATM-related holding is estimated at Euro 400 million[7] in 1996 (this figure does not take account of inconvenience to passengers). There are, however, less reliable figures for analyzing the other causes of delays (due to technical problems with aircraft, loading of luggage and passengers, etc.). The late arrival of aircraft flying the previous flight segment, which is itself partly caused by ATM, is the main known cause of delays (around 40%).

Information regarding in-flight delays is still less widespread, but they also contribute to late arrivals

[7] The average cost of one minute's holding on the ground is Euro 18.5 (source IATA).

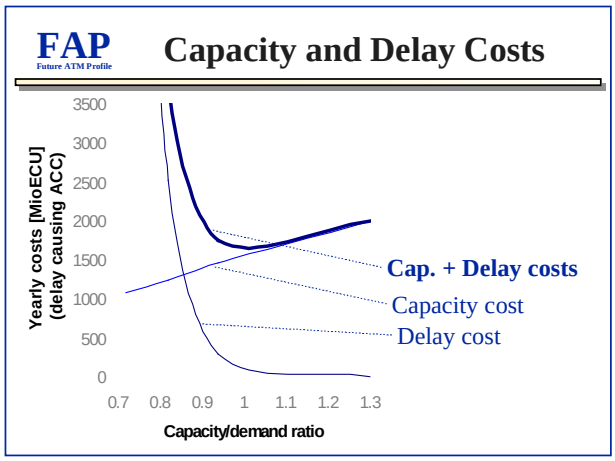
and penalties.

ATC capacity thresholds are largely dictated by the limited workload that can be absorbed by controllers in each "sector"[8] of airspace. The traditional method of increasing capacity by subdividing airspace into increasingly smaller sectors will reach its limits around 2005 in areas with the highest traffic density. This is the basis for the notion of the "capacity wall"[9]. The capacity of increasingly larger portions of airspace will be limited by this "capacity wall" unless radically different ATM methods are introduced. The introduction of new communications, navigation, and surveillance (CNS) technologies, such as satellites, is useful only insofar as it promotes the use of more efficient procedures or reduces the cost of the infrastructure, but does not provide a solution per se.

## Cost effectiveness

The cost of the ATM service in Europe, an amount of Euro 3,500 million in 1997, is recovered entirely through the route charges paid by airspace users (air transport, military and general aviation). Route charges account for some 4% of the operating costs of the major airlines. On top of these come charges for terminal and airport services. Total charges are of the same order as fuel costs (10% of operating costs).

There is great pressure from airspace users to reduce the costs of the ATM service. However, the objective should not be to minimize route charges at any price. There are trade-offs between a number of performance items such as costs and delays. The following picture shows that there is an optimum capacity/demand ratio where the cumulated cost of capacity and delays is minimum. Although some validation remains to be done on the cost function of capacity (supposed to be linear here), the result remains.




## Other performance areas

A reduction in the operational penalties associated with non direct routes in upper airspace could save hundreds of millions of Euro per annum. Other performance areas, such as predictability, are considered extremely important in the USA. Indeed, accurate forecasts of traffic conditions a number of months in advance would enable reliable timetables to be fixed and observed, which would be extremely beneficial to not only to airlines but also to passengers.

Lastly, insufficient ATM service quality also has a cost. The PRC should therefore act to identify the optimal balance between the various performance factors (cost, capacity, etc) which are themselves linked to production factors (staff, investments, etc.) and work towards achieving this balance.

[8] A control sector is the geographic unit of organisation for control tasks, under the responsibility of a team of controllers.

[9] See the articles by J. Villiers in issues 59 et 60 of the *Institut du Transport Aérien* magazine.

## Economic and financial stakes

The following table summarizes orders of magnitude for the economic and financial stakes associated with ATM in Europe. Being based on rough estimates, conclusions there have to be taken with caution. The table tends to indicate that a 10% productivity gain in ATM services, a stabilization of delays or a 50% reduction in the lengthening of routes would each bring savings of the order of hundreds of million of Euro per annum as compared with natural trends. These objectives are ambitious, but not unattainable.

| | Forecast/ actual value | Date | Assumed improvement | Annual savings |
|---|---|---|---|---|
| Route charges | 3500<br>5200<br>7000 | 1996<br>2005<br>2010-15 | <br>- 10%<br>- 30% | <br>+ 500<br>+ 2100 |
| Ground delays caused by ATM | 400<br>800[10]<br>2000[10] | 1996<br>2000<br>2005 | <br>- 50%<br>- 80% | <br>+ 400<br>+ 1600 |
| Ground delays caused by insufficient airport capacity | 500<br>1000[10]<br>2500[10] | 1996<br>2000<br>2005 | <br>- 50%<br>- 80% | <br>+ 500<br>+ 2000 |
| In-flight delays | not available | | | |
| Lengthening of routes | 600<br>900 | 1996<br>2005 | <br>- 50% | <br>+ 450 |

The main value added by ATM could be to enable further air transport growth. A doubling of traffic would increase the annual revenue of air carriers in Europe by some Euro 40,000 million per annum, with direct and indirect benefits for employment and economic growth. Several factors could, however, restrict such growth, in particular the capacity of the major airports, environmental pollution, and ATM capacity. All these restrictions must be overcome if this added value is to be created.

## Cost and financing of ATM

Air traffic control has traditionally been financed from State budgets, since it is the responsibility of States pursuant to the Chicago Convention signed in 1944. This is still the case in the USA, where the Federal Government levies a tax on tickets for commercial flights and on fuel for private flights. In Europe, receipts are being increasingly assigned to ATC service providers, who increasingly have the status of private companies. Users now fully finance the ATM service in Europe through charges. The recent ICAO Conference in Rio highlighted the importance of associated financing and control mechanisms for the implementation of ATM/CNS systems. The EUROCONTROL Organization has a powerful and effective means of financing in the form of its route charges mechanism.

EUROCONTROL's Central Route Charges Office (CRCO) is responsible for the recovery of charges on behalf of the Participating States. These totaled Euro 3,500 million for 27 European States in 1997. In Europe, route charges are proportional to the distance flown and the square root of the aircraft's weight. This formula enables costs to be apportioned according to contributing capacity, without excessively penalizing operators of the heaviest aircraft. It is accepted as fair and equitable by all parties. The service unit is based on control for an aircraft weighing 50 tons over a distance of 100 kilometers. The unit rates are determined by the enlarged Committee for Route Charges in such a way that 100 % of the costs are recovered.

Since January 1998, flight distance has been calculated on the basis of the Route length per State Overflown [11], as opposed to that of the most frequently flown route, and the charges are paid to the State actually overflown. Choice of route will henceforth introduce an element of competition between ATM service providers, particularly in Europe, where national airspaces are rather small. Nevertheless, the principle of recovery of costs still applies today, i.e. a State may in principle bill users for the entire cost incurred, irrespective of the amount. Apart from having an inflationary effect, this formula offers no encouragement to increase capacity or the quality of the service provided, since the costs

[10] Extreme scenario in which no further capacity is created (Do nothing)

[11] Calculation method known as " RSO "

are recovered regardless of the service offered. The RSO system could therefore achieve full efficiency only if all the charges paid were linked to the service actually provided, for example by means of a maximum price mechanism.

Although the users, who are also the payers, have no direct authority over the setting of the unit rates, they nevertheless exert an influence, and average unit rates have remained relatively stable over a long period (see figure 3). As from 1998, they are entitled to attend all meetings of EUROCONTROL's decision-making bodies with observer status. The stagnation of traffic at the beginning of the 1980s led to a substantial reduction in ATM investments and caused capacity to stagnate. The considerable traffic growth at the end of this period brought a substantial increase in the delays caused by ATM, and ultimately led to measures being taken by ECAC Transport Ministers as described at the beginning of this paper. The situation was redressed between 1990 and 1994 at the expense of an increase in the unit rates, despite the fact that all other air transport costs were falling. The average unit rate then fell from 1995 onwards owing to pressure from users.

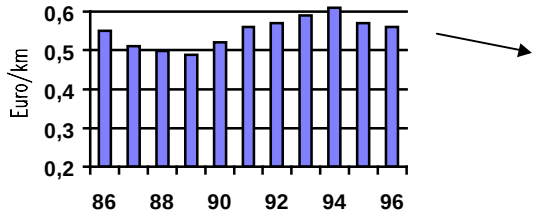



**Figure 3: Average rate of route charges in Europe (deflated)**

The above figure also shows that it has hitherto been possible to increase capacity at a relatively stable long-term unit cost. This in itself is remarkable, since the traditional method of creating capacity involves dividing airspace into ever smaller control sectors' a process with diminishing return. Thus, increasing the number of sectors by 40% only increases capacity by approximately 20%. Productivity gains have therefore in the past compensated for the lower efficiency caused by sub-dividing airspace. Users are now calling not only for increased capacity and reduced penalties, but also lower unit costs. This adds an extra dimension to the challenge faced by ATM services.

## Penalties associated with air traffic control

ATM generates direct costs associated with route and airport charges, and also penalties due to delays, imposition of longer flight paths or flight times, non-optimal use of aircraft in the vertical plane, etc.

*Indirect routes*

Multisensor and/or satellite surface navigation systems now enable aircraft to follow an optimal route between two distant points without overflying radio beacons. Nevertheless, controlled aircraft still often follow a network of published routes, since this facilitates control (low rates of closure at the same altitude, finite number of crossing points to monitor, more orderly and predictable traffic). Average route lengthening is of the order of 10% (45% in certain cases). It would be possible to reduce this by approximately half by means of direct routes, since departure and arrival paths around airports must continue to be highly organized. The financial benefits would be of the order of Euro 450 million per annum in 2005, and emission pollution would be reduced by 5%.

### Summary of expected improvements in performance

The challenge facing ATM to deal with a doubling of air traffic in the years to come, may be summarized as follows:

- the "capacity wall" must be breached around 2005, otherwise ATM delays will mushroom to such an extent that aviation development will be jeopardized,
- the rate of incidents/accidents per flight hour must be reduced to a quarter of the current present figure,
- unit costs must be reduced,
- service quality must be improved and needless penalties reduced.

This is summarized in the following table.

| | Natural trend from 1995 to 2010/2015 | Assumed target |
|---|---|---|
| Traffic | x 2 | x 2 |
| Accidents/incidents | x 4 | x 1 |
| Airport/ATM delays | x 10-20 | x 0.5 |
| Charging rate | x 1 | < 1 |
| Flight penalties | x 2 | x 1 |

The EUROCONTROL Organisation's objective could therefore be to manage ATM and the corresponding CNS infrastructure in such a way that traffic demand is met, that agreed minimum levels of safety, environmental sustainability and equity performance are met, and that the performance of the ATM system is optimized for specified key performance areas. The Performance Review Commission could play a decisive role here.

It is reassuring that the R&D work carried out in the last ten years, in Europe in particular, enables these challenges to be faced with reasonable confidence. However, the benefits will materialize only if the other limiting factors such as airport capacity and environmental sustainability are tackled concomitantly.

## Other limitations on growth

### Airport capacity

As we have seen above, only about twenty of some 800 airports capable of receiving commercial traffic in Europe are responsible for the majority of airport delays. Airport delays are the direct consequence of mismatching capacity and demand at the major airports, even where demand is limited by scheduling committees, which do not allow the number of scheduled flights to exceed the number of slots available. Much is now known about airport-related delays owing to the work carried out by CODA[12]. These analyses are, however, based on data which are still insufficient or incomplete.

Many factors combine to increase and concentrate demand on the most overloaded airports, in particular the formation of world-wide alliances between the major airlines, built around "hubs". This causes traffic concentrations at certain airports at certain times, with waves of arrivals, followed by waves of departures. In order to reduce airport constraints, some airlines establish their hubs at secondary airports, which are reserved almost entirely for themselves, like Delta Airlines at Cincinnatti. Such developments are dictated by market opportunities and are therefore difficult to predict.

On the other hand, increasing airport capacity is a complex matter entailing political considerations (traffic rights, slot allocation, environmental constraints, intermodal transport policy). It is difficult to build new runways and landing frequency is limited by physical phenomena (wake turbulence, braking time, runway clearance time). ATM can only optimize the use of existing capacity.

The distribution of traffic between airports will thus have to change in line with the market, competition between means of transport and with means of telecommunication, environmental pressures, market trends, etc. ATM will have to be able to adapt to the new traffic flows.

In conclusion, airport capacity will be a decisive factor influencing air transport growth in Europe in the years to come, as is already the case in the USA.

[12] The Central Office for Delay Analysis, a unit run by EUROCONTROL.

Initially, we need to get a better idea of the current causes of airport delays and it is even more essential to predict how they will develop. To this end there is a need for reliable, consistent sources of information on all major European airports, and for demand forecasts which are as accurate as possible. An initial step in this direction might be to encourage OOOI[13] reports to be submitted for scheduled flights, as is already the case in the USA.

### Environment

Preservation of the environment might be a major constraint on the development of air transport, in particular the control of noise pollution. Certain airports (such as Amsterdam and Orly) are already subject to major environmental restrictions. ATM can influence the impact of aviation on the environment only marginally by reducing flight distances (around 5% of emissions) and through less noisy take-off and landing procedures. Progress will essentially have to come from engine improvements and regulations intended to eliminate the most noisy aircraft.

## Conclusions

Air transport has a good potential for growth and for creation of highly qualified jobs in a context of European integration and globalisation. Nevertheless, the associated benefits will materialize only if the limiting factors, in particular airport capacity and environmental pollution, are addressed with the necessary vigor.

As far as ATM is concerned, major changes in systems and methods of flow control, airspace management and aircraft separation will be needed to breach the "capacity wall" predicted around 2005 in areas of high-density traffic.

The initiatives under way, in particular within the framework of the revised EUROCONTROL Convention, leave little doubt that solutions are being found, and will continue to be found, to enable air traffic control in Europe to satisfy users' requirements in terms of quantity and quality in the decade to come. Airspace users, who bear the entire cost of the ATM service, will undoubtedly be exerting pressure to ensure that these promises are kept. Swift and effective action to improve the performance of the ATM system in Europe should be a decisive factor in this process.

[13] OOOI: Out, Off, On, In, i.e. off-block, take-off and landing times