COMMISSION OF THE EUROPEAN COMMUNITIES

Brussels, 06.03.1996
COM(96) 57 final

AIR TRAFFIC MANAGEMENT

Freeing Europe's airspace

WHITE PAPER

(presented by the Commission)

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This White Paper examines the background to the current situation in air traffic management in Europe, and the shortcomings of the present arrangements, before defining a "single ATM system for Europe" and, finally, outlining the Commission's views on the best institutional arrangements for the future. It is supported by an Annex which looks in more detail at the different aspects of building a unified system; and four technical Appendices.

I. BACKGROUND

(a). Definitions

1.- The term "air traffic management" (ATM) is generally accepted as covering all the activities involved in ensuring the safe and orderly flow of air traffic. It comprises three main services :

- Air traffic control (ATC), the principal purpose of which is to maintain sufficient separation between aircraft and between aircraft and obstructions on the ground to avoid collisions. However, this safety objective must not impede the flow of traffic and must therefore meet the needs of users. Appendix 2 describes how this service is provided in practice, and the division of responsibilities between the various parties involved.

- Air traffic flow management (ATFM), the primary objective of which is, again on safety grounds, to regulate the flow of aircraft as efficiently as possible in order to avoid the congestion of certain control sectors. The ways and means used are increasingly directed towards ensuring the best possible match between supply and demand by staggering the demand over time and space, and also by ensuring better planning of the control capacities to be deployed to meet the demand. The Commission communication on congestion and crisis in air traffic[1] describes how this service is performed.

- Airspace management (ASM), the purpose of which is to manage airspace - a scarce resource - as efficiently as possible in order to satisfy its many users, both civil and military. This service concerns both the way airspace is allocated to its various users (by means of routes, zones, flight levels, etc.) and the way in which it is structured in order to provide air traffic control services.

(b). The basic ATM functions

2.- Air traffic management comprises two distinct, basic functions - one "regulatory", in a broad sense; and the other "operational".

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[1] COM(95)318 final, 5.7.1995.

The first of these functions involves setting broad objectives in terms of the safety, quantity, quality and price of the services to be provided and taking steps to ensure that they are met. It also involves the allocation of airspace to its various users, including military users, and all the measures needed to meet a wide range of _other_ policy objectives to do with such issues as environmental protection, town and country planning, national defence and meeting international commitments.

The second function is the actual provision of services, for reward, within the regulatory framework provided by the first function. This is a quasi-commercial activity, the safety aspect of which is of course essential.

(c). The participants

3.- These services and functions are the responsability of individual countries, which have put in place the necessary organisations and infrastructure by their own. In few cases, two or more countries have used regional organisations to provide some of the corresponding services and functions jointly on their behalf : in Europe, EUROCONTROL's control centre at Maastricht provides air traffic control for the upper airspace of the Benelux countries and Northern Germany under specific agreements between the Agency and the States concerned. EUROCONTROL has also been given responsability for setting up and implementing a Central Flow Management Unit (CFMU) to provide ATFM over nearly all of Europe.

The regulatory framework in which the operational function is provided nevertheless always remains a national prerogative, except when exist "ICAO Standards", which are binding international commitments, or "EUROCONTROL Standards" made mandatory by the Community (Directive EC/93/65[2] - see paragraph 8).

As a consequence, each State is almost entirely free to decide the level of service to be provided and the means to be employed for this purpose, with the result that the technology used and the results achieved vary very widely from one country to another, making the overall system less efficient than it should be.

4. To overcome this problem, if only in part, most countries in the world have felt it necessary to develop their international cooperation. They have done so on the basis of the principle of "full and exclusive sovereignty of each country over its own territory", as established in the Chicago convention of 1944 which laid the foundation of the global system of international air transport.

In this context, the International Civil Aviation Organisation (ICAO) was set up to define and adopt the common rules - the "ICAO standards" - needed to make the system interoperable so that any one aircraft could travel anywhere in the world. This

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2 OJ N. L 187, 23.1.1993.

organisation, which has 184 member countries around the globe, is also responsible for ensuring that the services correspond as closely as possible to the needs of the users by adopting and amending from time to time Regional Air Navigation Plans, including the European Regional Air Navigation Plan. It may, consequently, give certain States responsibility for supplying such services to aircraft crossing international waters. It is nevertheless a relatively flexible framework, within which it is possible to notify differences from the common rules, while the undertakings given in the Regional Plans are not legally binding.

Groups of States have also chosen to cooperate more closely at regional level and, in some cases, to consider actually integrating their national services. It was for this reason that EUROCONTROL[3] was set up in 1960 by an international convention, to provide air traffic control for the entire upper airspace of its Member States. This, however, represented too great a transfer of sovereignty for some of the first of its member countries : even before the Convention entered into force, France and the United Kingdom reclaimed control of the whole of their own airspace, and Germany later largely followed suit. Consequently, EUROCONTROL was given essentially a coordinating role in planning and research, and its Convention was supplemented by a multilateral agreement under which it was given responsibility for collecting route charges.

In parallel with these developments, and in view of the lessons learned from over-ambitious attempts at integration, ICAO reinforced the existing mechanisms for cooperation at regional level by setting up the EANPG,[4] which meets once or twice a year as necessary and works more or less continuously on updating and monitoring the European Regional Air Navigation Plan.

At a more political level the European Civil Aviation Administrations have established, under the aegis of the Council of Europe, the European Civil Aviation Conference (ECAC)[5] where they can discuss and co-ordinate their various policies.

5. Up until now, despite the existence and continuing development of its competence in aviation, the Community has no formal status in any of these organisations. It is only involved as an observer, in certain aspects of their work.

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3 Today, EUROCONTROL has 20 Member States (the States of the European Union except Finland and Spain, plus Cyprus, Hungary, Malta, Norway, Slovenia, Switzerland and Turkey). The multilateral agreement on route charges covers these same countries plus Spain.

4 European Air Navigation Planning Group.

5 ECAC is now composed of 33 European States, including all EU Member States.

III. AIRSPACE CONGESTION

(a) The problem

5.- Air traffic control was initially regarded primarily as a safety service, the constraints of which in terms of cost and delays - which were in fact relatively minor - had to be tolerated. It did not begin to be seen as a restrictive factor before the 1980s. Until then, airports has been regarded as the main bottleneck and it was thought that the development of air transport was therefore only limited by the number of runways which the environment would tolerate.

In 1986 only 12% of intra-European flights were delayed by more than 15 minutes (for whatever reason: ATC, weather, airline, airport, etc.), but the figure rose to 20% in 1988 and 25% in 1989, chiefly because of infrastructure congestion.

This appeared inacceptable, not only because of the direct overcost of delays to airlines evaluated at 2000 MECU[6] annually, but also in view of the millions of hours wasted by the travelling public, as well as the deteriorating perception of air transport at a time when it faced increased competition from other transport modes.

Remedial measures, and the concomitant investment programmes described hereunder, have considerably improved the situation in the early 90s: in 1993, the number of flights delayed by more than 15 minutes fell back to its 1986 level of 12% despite a 50% increase in traffic.

Since mid-1994, however, according to the Association of European Airlines (AEA), delays have been increasing again and over 1995 the proportion of flights delayed by more than 15 minutes was 18.4%.

Appendix 2 describes this trend and attempts to quantify its economic impact.

(b) The initial response

6.- These developments led to general frustration, and showed that inadequate capacity in air traffic control systems could also jeopardise the liberalisation process already under way and constitute a major obstacle to the free movement of persons, especially in inaccessible and island regions. Accordingly, most of those involved demanded radical action to deal with this problem, the resolution of which would bring positive social and economic benefits.

Accordingly, towards the end of 1988 the Commission proposed a number of Community measures in this field[7].

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6 Sources : IATA, late 1980s; INSTAR "Phase 0" report, 1995

7 COM(88)577 final. These proposals are now being withdrawn by the Commission.

The European Parliament also considered this issue and on 18 September 1992 adopted a resolution on the saturation of airspace[8] which advocated the establishment of a single air traffic management system based on the Community's institutional mechanisms.

The Council did not adopt the Commission's proposals, however, and on 18 July 1989 adopted a resolution on air traffic system capacity problems[9] which saw multilateral cooperation within ECAC as the best way of resolving them; and called upon the Commission to help EUROCONTROL to accomplish its tasks in this connection, using Community legislative instruments as appropriate to ensure that decisions or resolutions adopted by the competent international bodies are actually implemented.

7.- In parallel, the ATM community was itself taking stock of the situation and various strategies were devised to improve it:

(a) In 1988 it was decided that ATFM activities should be centralised in order to make the most efficient use of the available ATC capacities with the aid of a full picture of supply and demand in Western Europe. EUROCONTROL was asked to establish a Central Flow Management Unit (CFMU), which has been set up gradually since 1992 and will be fully operational in the summer of 1996 when all the national air traffic flow management activities will have been transferred to it.

(b) The ECAC en-route strategy was adopted in 1990. This resulted in the launching of the European Air Traffic Control Harmonisation and Integration Programme (EATCHIP) for which EUROCONTROL was given responsibility.

The programme calls for the adoption of joint rules, procedures and specifications to ensure the interoperability and interaction of the various national systems. An EATCHIP Work Programme (EWP) has been established: in 1994 the annual expenditure under the EWP amounted to 68 million ECU, and this will have to rise even further between now and the end of the century. Its implementation will henceforth be a standing EUROCONTROL function.

At the same time, individual countries have agreed to improve the capacity and performance of their national systems in order to meet, by 1995 and 1998, jointly defined operational objectives to ensure the overall consistency of investment and avoid the emergence of weak links. The details of the various national programmes make up the Convergence and Implementation Programme (CIP). The ECAC countries have invested an estimated ECU 1 200 million per annum on average since 1992 in the modernisation of their national systems, and it is considered that a similar outlay will be needed over the next three years in order to implement the CIP.

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8 OJ No C 284, 2.11.1992.

9 OJ No C 189, 26.7.1989.

EUROCONTROL and its member countries have also agreed to undertake a major effort on research and development to define the concepts and develop the tools required to meet foreseeable long-term needs. The aim is to bring about a uniform European Air Traffic Management System (EATMS).

(c) Finally, in 1992 a strategy was established to improve the interface between airports and air traffic services (APATSI). Responsibility for monitoring this programme is shared between EUROCONTROL and the ECAC Secretariat, while the individual countries are responsible for implementing it. Within this framework, procedures have been developed for improving runway capacity and a new body, the Central Office for Delay Analysis (CODA), is being set up for collecting and analysing data on delays so as to determine their causes and take appropriate steps to reduce them.

8.- This pragmatic approach is supported by all concerned, particularly the airline associations actively involved in EUROCONTROL's standardisation work.

For its part the Commission, as requested by the Council, has lent its support to the implementation of the ECAC strategies through various forms of financial assistance; and the adoption of a Directive making the "EUROCONTROL standards" mandatory within the Community[10] (see also paragraphs 28 and 29).

(c) The present state of play

9.- As already seen, there are now signs that the rate of delays is beginning to worsen again seriously after the significant improvements in recent years. The figures for 1995 are amongst the worst ever recorded. On average, some 18.4% of flights were delayed by more than 15 minutes over the year; in September, the figure was back to the 1989 level of 25% (compared to 17.5% in September 1994); and, in December, severe weather contributed to a figure as high as 27.1% (compared to 15.2% in December 1994).

Although the cost of ATC delays to airlines had steadied at around ECU 2 000 million annually despite the increase in traffic, this level remains extremely heavy as it accounts for some 5.5% of the total cost of intra-European air services.[11] The initial conclusions of the study by ECAC, with the support of the Commission, on organisational arrangements (INSTAR) showed that there is still considerable room for improvement in the quality of the service provided. Taken together, a reduction in delays and an improvement in the network of air routes could result in an annual saving to airspace users of some ECU 2 000 million;

10.- Moreover, the costs of providing ATC en-route services increased from 1986 to 1993 by 60% in real terms (120% at current value) - that is, faster than traffic has grown

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[10] OJ No L 187, 23.1.1993, Directive 93/65

[11] Sources: IATA and AEA, late 1980s; INSTAR "Phase 0" report, 1995

and accounted for 5.6% of the cost of intra-European air services, compared with 3.8% in 1986. The figure may even be as high as 20% in the case of regional services.[12] The INSTAR study also concluded that steps could be taken to curb further rises in the cost of this service, thus saving a further ECU 600 million per year in charges to airspace users. That is roughly one quarter of the total amount paid today.

11.- At their informal meeting in Palma on 15 July 1995, the Community Transport Ministers recognised the need for further progress in this field to achieve the objectives of economic efficiency, social cohesion and sustainable mobility, as laid down in the Treaty. They also expressed the wish that this White Paper, then being drafted, would put forward proposals to that effect.

This view is broadly shared by the European Parliament, as can be seen from its various resolutions on the subject, particularly those adopted on 27 September 1994 on air traffic control in Europe[13] and on 14 February 1995 on the way forward for civil aviation in Europe.[14] The Parliament considers, moreover, that the Community should be more involved in the process. It has therefore called for the "harmonisation and integration of the different national ATC systems, under the aegis of the EU, and the establishment of the basic framework for a single unified ATC system covering the entire Community airspace and controlled by a single Community Civil Aviation Authority", and has requested the Commission "to draw up, as soon as possible, a complete and detailed timetable to achieve this", reminding the Commission "of its powers in the event of non-compliance by a Member State with the obligations that are incumbent on it under the Treaty on European Union."

This is the view generally taken, too, by a number of airline associations and other airspace users, who have called for a full exercise of Community competence in this sphere.

The "Committee of Wise Men", set up by the Commission in 1992 to work out an overall European air transport policy, also echoed this view.

12.- As the technical and operational value of the ECAC strategies described here above, is recognised by all parties involved, it is clear that the lack of further progress and even the current deterioration is largely attributable to an increasing inability of the present organisational arrangements to cope with the growing demands required of them. The Commission has decided, therefore, to review what needs to be done in Europe to build an efficient Air Traffic Management system so as to identify the organisational shortcomings which slow down, hamper or block further developments. The results are set out in the Annex to this paper, and are summarised in the

12 See Appendix 2.

13 OJ No C 305, 31.10.1994.

14 OJ No C 56, 6.3.1995.

following chapter. On this basis the Commission has developed its views on the appropriate organisational changes required; and how the Community could best play its role in achieving these objectives while respecting the principle of subsidiarity or proportionality and taking account of the experience and expertise of the international organisations already involved.

III. THE SHORTCOMINGS

A fragmented picture

(Sections 3.2, 3.4.2, 3.5, 3.7, 4.1, 5.1 and 5.5 of the Annex)

13.- Establishing a unified European air traffic management system with the capacity to satisfy the foreseeable needs in acceptable economic conditions would be a complex undertaking requiring the development of new concepts and technologies and heavy investment in equipment and human resources. But first of all, there is a need for a full understanding of all the aspects if the right decisions are to be taken and implemented in good time.

At the moment, the only means of obtaining this comprehensive picture is by getting information from various bodies working in parallel - which only adds to the confusion in an already highly complex field, and wastes resources and effort. Apart from the Community's own activities, which are described in paragraphs 28 and 29, these bodies are:

- EUROCONTROL and the ICAO European Regional Office for air traffic flow management;
- the EATCHIP Project Board, for en-route strategy, the definition of common objectives, procedures and specifications and monitoring their implementation;
- the APATSI Project Board, for the airport/air traffic services interface;
- the Joint Aviation Authorities (JAA)[15], for performance levels and specifications for on-board equipment;
- NATO's Committee for European Airspace Coordination (CEAC), for the co-ordination of military and civil requirements;

15 The Joint Aviation Authorities are an informal grouping of national aviation administrations, which deals with the saety of aircraft and their operators.

- the ICAO's European Air Navigation Planning Group (EANPG), for general planning and liaison with neighbouring countries and regions.

The adverse effects of this fragmentation become particularly apparent when it comes to standardisation or research and technological development, where different bodies are responsible for different parts of what should be considered as a single, comprehensive system. Management of airspace, air traffic flow planning or the management of crises also suffer from the lack of a global approach.

Although ECAC could possibly be given responsibility for overall coordination, its present Secretariat lacks the resources to perform this role; and in any case it is by no means certain that this body has either the political dimension or the legitimacy to enable it to do so properly.

There is a need to establish a single body capable of bringing together all the elements necessary to develop a comprehensive European ATM policy.

Lack of decision-making mechanisms

(Sections 1.1, 3.2, 3.3, 3.4.1 and 3.4.3 of the Annex)

14.- Any comprehensive approach to ATM must also be accompanied by appropriate mechanisms for efficient decision-making. Today, however, the various bodies operate mainly on the basis of consensus, as far as the regulatory aspects of ATM are concerned. This slows down the implementation of the ECAC strategies since, now that nearly all the easiest points have been settled, the process is starting to stumble over trickier issues. This is the case with, for example, the use of airborne collision avoidance systems, the drafting of common procedures and specifications, the use of VHF frequencies and the reduction of vertical separation, on all of which decisions appear to be hard to reach through the EATCHIP processes. By contrast it seems probable that decisions could have been reached on all these points if rule-making had been based on majority voting.

But above all, the present state of affairs cannot go on as it is because it does not recognise the fact that airspace must be regarded as a common resource which has to be managed in the best interests of all users. The need to take national defence requirements into consideration is sometimes used as a justification for such an approach, but these concerns could easily be met by instituting proper safeguards.

There is a need to introduce effective decision-making processes based on majority voting instead of unanimity, together with appropriate safeguard mechanisms to deal with exceptional cases where national security could be threatened.

Lack of decision-making aids

(Sections 3.1, 3.6.1, 4.2, 4.3, 5.1 and 5.2 of the Annex)

15.- A major weakness in the present arrangements is the lack of management information to assist the decision-making process. This is already widely recognised, and several of the programmes in EATCHIP and APATSI are intended to address the causes.

The first cause is the lack of suitable indicators to access the quality and quantity of the service provided or to be supplied. This hampers traffic flow management and planning; and hinders any detailed cost-benefit analysis of major investment or of options under consideration for boosting the capacity of the system, such as Reduced, Vertical Separation, Area Navigation, etc.

The second lies in individual countries' reluctance to reveal details of costs, investment, manpower, etc. This lack of transparency makes it difficult to check that the common objectives are attained, to conduct cost-benefit analyses on the appropriate scale or simply to make comparisons to evaluate the performance and efficiency of all involved.

The third stems from the inadequacy of the human and technical resources available to carry out the analyses required to support the decision-making process. This can be explained by the fact that, until comparatively recently, air traffic control services were invariably provided by national authorities as a monopoly public service in which users had little say. That, however, is certainly no longer acceptable today, not least for the users, and every decision must be fully justified on the basis of technical, economic and social criteria in order to make sure that they will give the expected results in terms of safety and capacity; ensure the competitiveness of the European economies; and be acceptable to the human environment.

There is a need for a stronger support for decision-takers, which would be able to provide them with appropriate information and well-prepared proposals.

Inefficient use of available resources

(Sections 3.2, 3.5, 3.7 and 4.2.2 of the Annex)

16.- The poor use of available resources reflects the approach of ATC authorities which seek, first of all, to solve their particular problems on their own. This can be seen at three levels.

The most obvious, of course, is the proliferation of types of particular equipment, both civil and military, where a joint approach would have allowed more rational siting and operation. This holds true especially for communication, navigation and surveillance systems, but applies also to control centres themselves and ATM subsystems. One good example of what closer cooperation can achieve is the Initial Flightplan Processing System (IFPS), set up to assist the establishment of the Central Flow Management Unit (CFMU).

The second level is in the approach taken in making technological choices. In particular, the ATM sector appears to be denying itself access to techniques - particularly in the case of telecommunications and data transmission applications - which have already proved their worth in other fields. This seems to be due to a lack of systematic evaluation of and experimentation with new technologies which could be used for air traffic management.

The third can be seen in the procedures for drafting specifications and common standards. Today the ATM community acts as legislator, standards-setter, customer and engineer. This complicates and slows down the standardisation process and distances it from what is happening in industry. Instead, the industry could play its role in this sector as it does in others. Enlisting the help of standardisation bodies would be a better means of sharing the work to be done and, therefore, enabling the legislative bodies to concentrate more on the matters for which they are specially responsible. Establishment of a certification and labelling mechanism would also ease the task of the industry and customers and improve the functioning of the internal market.

There is a need for a central authority to decide on common options, allocate tasks and rationalise investments.

Lack of means of following up decisions

(Sections 3.2, 3.5, 3.7 and 4.3 of the Annex)

17.- The need for effective decision-making mechanisms has already been discussed, but experience shows that, if a decision is to be properly applied in practice, monitoring is needed to ensure that it is correctly understood by all concerned; that all the means needed to carry it out are available; and that any failure to comply properly is detected and corrective action taken in good time.

Paragraph 15 described the shortcomings in the area of decision-making aids. The same shortcomings - absence of adequate performance indicators, lack of transparency and insufficient resources - are also hampering the establishment of an objective, independent evaluation mechanism.

In any event, the institutional arrangements linking the parties concerned allow no effective corrective measures other than the obligation to comply with the "EUROCONTROL standards" made mandatory in the Community through the mechanism established by Directive 93/65.

So long as regulatory decisions can be taken only by consensus, and therefore only cover action which would have been undertaken spontaneously in any case, this is possibly not too critical. The situation would be very different, however, were decisions to be taken by majority vote.

This shortcoming is especially apparent when it comes to monitoring the implementation of the Convergence and Implementation Programme (CIP), where it is particularly difficult to know whether individual countries are in fact achieving in good time the joint objectives.

Similar suspicions persist with regard to application of the common procedures and specifications, particularly for non-Community countries where no measures seem to have been taken to implement the EUROCONTROL standards.

There is a need for a central authority able to ensure that decisions are applied effectively and uniformly, and to take any necessary remedial steps if they are not.

Lack of tools for implementation and support

(Sections 3.5 and 3.7 of the Annex)

18.- Not all decisions can be absolutely mandatory, particularly when implementing them depends on such imponderables as the availability of capital or the technical feasibility of certain projects. This is particularly true of investment, and research and technological development. It is then necessary for the decision-makers themselves to have sufficient resources to ensure that the policies they decide are carried through.

Apart from some Community funds, however, there are no other collective financial resources available to the ATM community which can help certain members to attain the objectives of the CIP, although such resources are essential.

Further, the resources available both to EUROCONTROL and individual countries are far from adequate to meet the research and development requirements essential for working up the ideas and techniques needed to satisfy the demand foreseeable in the medium to long term. Moreover, since these resources come from en-route charges, users are reluctant to see that money allocated to long-term research and technological development activities which, they consider, should come under industrial rather than transport policy.

There is a need for a central authority, with the ability to dispose of appropriate financial resources to support the implementation of agreed ATM policies.

Inadequate cost control

(Sections 4.2, 4.2.1, 4.2.3 and 4.4 of the Annex)

19.- Air traffic control is, first and foremost, a safety function provided mainly by public administrations or authorities as a public service. Because, up to now, it has generally not been treated as a commercial service, cost control has not been one of the foremost concerns. This tendency has been aggravated partly by the institutional framework within which the providers of the service operated; and partly by the methods used for recovering costs.

On the first of these points, the fact that the services are provided by the public sector imposes administrative constraints which mean they cannot take advantage of all the opportunities available to private sector business managers to motivate their staff and fund their operations at the lowest possible cost. Although changes in various countries are helping to reduce this handicap, there is a need to establish a broad economic environment more condusive to managerial efficiency.There are various possible ways of achieving this, which need to be explored further.

As for the second point, the knowledge that all one's expenditure will always be recovered through user charges to customers, irrespective of their number, together with a non-profit-making ethos, means that suppliers of ATM services lack a proper motivation to pursue cost-effectiveness.

There is a need to encourage the development of an appropriate organisational environment which would encourage the managerial responsibility of ATM providers and stimulate their cost-consciousness.

IV. DEFINING A SOLUTION

20.- There can be no question that solving the shortcomings identified in the preceding paragraphs will require a major restructuring of the organisational arrangements applicable to Air Traffic Management in Europe today. This would, in fact, mean setting up a single ATM system, since it appears clearly from the previous chapter that what is required above all is a central authority with a specific mandate, provided with the appropriate means to fulfill its tasks.

(a) The need to separate regulatory and operational functions

21.- As described earlier ATM comprises two main functions which require two very different skills - one based on legal and administrative competence, and the other on extensive technical knowledge and management proficiency.

These functions are so different that it is questionable whether any single organisation could perform them both equally well : such an organisation would naturally be reluctant to admit its own shortcomings and indeed might be tempted to use its regulatory powers to ward off the emergence of any alternative, competing approaches to air traffic management. Separation of the two functions would also encourage greater efficiency in the exercise of, and greater transparency in the allocation of responsibilities to each function.

Although the current shortcomings affect all aspects of ATM policy-making and service-provision, it seems apparent that most spring from weaknesses in the area of policy-making at the most strategic level, which then feed through to affect service provision as such.

There is a strong case, therefore, for concentrating efforts on improving the present procedures for strategic policy-making by creating a single regulatory authority, while leaving existing mechanisms for service provision very largely unchanged.This would take greater account of both the reality of the present situation and the principle of subsidiarity and proportionality as laid down in the Treaty, according to which collective action should be limited to those fields in which it is more effective than individual action, and should be in proportion to the objective to be achieved.

In any organisational reform in the field of ATM the two principle functions - "regulatory" and "operational" - should be dissociated as far as practicable, although there is a need for an in-depth analysis of how this could best be achieved.

(b) The operational function

22.- As far as the operational function is concerned - which can itself be subdivided into a number of sub-functions (the supply of communications, navigation, surveillance, ATC, air traffic flow management and other air navigation services) - it has been argued that setting up a single operator is the most radical way to create the single system Europe needs. According to its proponents such an approach would not only ease the provision of consistent ATC services throughout Europe regardless of national borders, but also allow for economies of scale by rationalising the investment required to provide these services. On the other hand setting up such a monopoly at Community or ECAC level seems hardly realistic given the practical reality of air traffic management in Europe today. Not only does it raise issues of national security and control but it is also doubtful whether it would actually cure some of the system's present weaknesses, particularly as regards cost-cutting. In addition it would inevitably hamper the development of competitive alternatives (see section 4.2.3 in the Annex). Accordingly, it might be better to leave individual countries to provide - as cost-effectively as possible, through public or private operators in accordance with their own practices - the services prescribed by the regulatory function.

At the same time, though, it is necessary to encourage the development of a more stimulating environment by setting pricing policy on a more commercial footing than it is at present (see section 4.4. of the annex), so as to encourage greater cost-consciousness.

It would also be up to the operators to choose ways of cooperating or competing with their opposite numbers in Europe according to their own strategy and interests. Some countries may choose to provide ATC services on a joint basis, as happens now with the Maastricht Centre operated by EUROCONTROL providing ATC services for Northern Germany, Belgium, the Netherlands and Luxembourg. A similar joint control centre is planned for several countries in central Europe. The regulatory authority should be able to provide support, on the lines described to in paragraph 18, to encourage such joint initiatives aimed at improving economic efficiency.

If individual countries opt for "monopolistic" solutions - as seems inevitable at this point, as far as most of the sub-functions are concerned - it should be their responsibility to set up the economic control mechanisms necessary to protect users. It could also be for the regulatory authority to define and set common economic targets so as to ensure a consistent level of performance throughout Europe.

As far as Member States of the Community are concerned, they will of course need to respect the requirements of the air transport policy and the provisions of the Treaty.

23.- There is, however, one sub-function which might justifiably be centralised in any case: traffic flow management. This has already been widely recognised, and indeed a centralised system is currently being set up under the aegis of EUROCONTROL.

In its Communication on congestion and crisis[16], however, the Commission expressed its dissatisfaction with the arrangement under which the CFMU is operating. In addition to its executive role, the CFMU should be given, within a future centralised authority, the powers which would make its decisions compulsory both for users and service providers, as far as flow planning, ATC slot allocation and targets for ATC capacity are concerned (see section 5 of the Annex).

Moreover, in a context of increased competition between providers of services, particularly in view of changes in the policy of calculating and redistributing route charges, decisions taken by the CFMU leading to a redistribution of traffic might have an important effect on the revenue and profitability of ATC bodies. It is therefore important that the CFMU's role should be more clearly spelt out and its relationships with its "customers" set on a contractual footing, so as to avoid continual disputes in the future.

This same structure should also take on a greater responsibility for the operational management of the "flexible use of airspace" concept at European level, since the techniques required for coordinating civil and military traffic are very similar to those used for managing and planning air traffic flows. Ideally its competence should even be expanded to include the management of the whole European airspace for all users, civil and military, with the same delegated authority, as suggested earlier.

(c). The regulatory function

24.- While arrangements for the provision of ATM services could remain the responsibility of individual countries, quite different arrangements must be considered for the "regulatory function". This function - which itself may be subdivided into sub-functions (safety, economic performance, investment, human resources, access to airspace, Research and Development, etc) - ought to be organised in such a way that it can draw up a single, unified regulatory framework, compatible with international standards and practices. That framework should cover:

- the level of safety to be met and ways of monitoring its achievement. This includes the definition of operational requirements and certification procedures applicable to ATM equipment and services;
- quantitative and qualitative objectives for the service to be provided, and timetables for meeting those objectives. This implies in particular the setting of quantified targets for the traffic to be handled, acceptable delays, the capacity to be provided and, possibly, the level of fees to be charged; it ought to include

16 COM(95) 318 final, 5.7.1995

also some kind of performance audit or management control to support the achievement of these targets.

- joint procedures and specifications to ensure interoperability and interconnection between the various components of the system, as well as methods for checking that these procedures and specifications are complied with;

- the collective management of certain scarce resources. This applies in particular to the use of available ATC capacity at peak periods or in times of crises, as well as to the allocation of airspace to its various users, civil and military;

- the preparation and implementation of a joint investment policy under which the cost/benefit analyses necessary for making rational choices would be carried out in common and using, as far as possible, an "equipment fund" to help weaker partners or to increase capacity in the most critical areas; such a policy should take into account the potential of private financing and public-private partnerships to be set up by the local operators;

- a human resources management policy which would help to develop a uniform level of services provision throughout Europe, and to facilitate the free movement of air traffic control staff; and

- a better co-operation in the field of Research and Technological Development, to ensure that new concepts come forward, are selected and are applied in a timely manner, while recognising that final decisions for RTD activities remain with the competent authorities.

To achieve this it is clear that the best way is to have a central regulatory authority able to build the comprehensive picture required and enjoying the power and resources advocated in paragraphs 13 to 18.[17]

V. OPTIONS FOR THE SINGLE ATM SYSTEM

Option 1 : a "European monolithic structure"

25.- As already mentioned, in paragraph 22, it has often been suggested that establishing a more efficient organisational framework requires very centralised solutions, similar

17 The Commission is conscious that the delicate question of maintaining the appropriate balance between safety and efficiency, could justify that operational requirements and safety aspects sould be regulated by a separate body, which, in view of the increasing integration of ground and on-board equipment into a global ATM system, should also be responsible for the safety of aviation as a whole. This will be considered in the work being done separately on the possible setting up a "European Aviation Safety Aurhority".

to the role originally envisioned for EUROCONTROL, which would bring both the policy-making and service-provision functions under one umbrella across all Europe. Although, by definition, such solutions would not meet the criterion that the regulatory and service-provision functions should be separated, they are considered as an option because they have been the subject of considerable discussion.

Establishing such a "monolithic structure" would involve transferring all the necessary powers and resources to a single entity, set up by a special Treaty with a mandate to manage, as efficiently as possible, the airspace for which it was responsible; and to provide, within that airspace, air navigation services as a universal public service. The procedures for this would be set down in broad outline in its constitution and spelt out in detail by a management body representing the various interests involved.

The proponents of a "monolithic structure" argue that a highly centralised organisation of this sort would bring considerable advantages in terms of accelerating the standardisation of ATS provision across Europe by giving responsibility both for service provision and future policy-making to a single entity, as in the USA. An organisation of this nature would, it is argued, be able to be far more authoritative and decisive than the present situation allows.

However, while a "monolithic structure" might be practicable in a single country already equipped with central decision-making and monitoring structures, it seems even less realistic than creating a single operator (see paragraph 22) insofar as it could exacerbate the difficulties raised. And indeed, some countries which already have such centralised structures are now beginning to question the merits of a monolithic approach and are considering a clearer distinction of the respective roles and responsibilities, as suggested earlier in this paper.

Option 2: "a solution limited to the Community"

26.- Using the powers and resources conferred on it by the Treaty, the Community might be able to provide answers to a number of the shortcomings identified, and provide for its Member States the single regulatory framework referred to above. This would be consistent with the objective of the Treaty to favour Community solutions when collective action would be - as in this case - more efficient than action by individual countries.

This would also be a logical consequence of the existence of Community competence in air traffic management.

Improvement of the European ATM system is essential for the completion of the single market in air transport and thus for achieving those objectives of the Treaty, particularly with regard to economic and social cohesion and the free movement of people. Community action in this area therefore forms an integral part of the common air transport policy and the Community should act to fulfil its legal and political obligations.

Moreover, paragraph 1 of Article 75 of the Treaty says that "the Council...will establish...measures to improve transport safety...". Since the purpose of air traffic management is, above all, to ensure the safety of air transport, and the purpose of action is to further improve this safety at a time when air traffic is growing steadily, there can be no doubt as to the Community's competence in this field.

27.- The Community has a number of legal powers through which it could take action here - Article 84(2) for matters directly linked to the furtherance of the common transport policy; Article 100A for harmonisation measures; Article 129 c for the interoperability and interconnection of national air traffic control systems; and Article 130H for research co-ordination.

Using these, the Community might be able to produce the comprehensive picture needed to solve the problems, and develop a single airspace managed as a joint resource regardless of national boundaries, by establishing a body with appropriate responsibilities. Ideally this would involve treating military and civil use of this communal airspace together ; and if Member States were concerned that this could affect their national security interests, appropriate solutions and safeguards could be found and applied, if there were sufficient political will to do so.

As for the actual provision of air navigation services in such a scenario, this would remain the responsibility of the Member States, but these services would have to comply with specifications drawn up by the Community in accordance with ICAO standards.

28.- The Community could use its organisational procedures - which have already proved useful in several other fields - in the field of ATM, to develop the necessary regulatory framework and to ensure that it is properly implemented. It has already done so with the adoption of Directive 93/65 on the mandatory technical specifications for the procurement of ATM equipment and systems; and it could do the same in many other aspects - some of which are already being pursued by EUROCONTROL and ICAO - so long as the provisions adopted are compatible with the standards and practices already agreed in these competent bodies. These include matters on which the Commission may decide to bring forward proposals in any case: the use of airborne collision avoidance systems; the adoption of common procedures; the use of VHF frequencies; the reduction of vertical separation; the setting of joint objectives on the capacity and quality of service to be provided, both in normal circumstances and in times of crisis; and the establishment of priority rules for making better use of the available capacity, as has already been done in relation to airport slots.

The Community can also initiate the development of industrial standards. This ability could be used to alleviate the regulatory workload, allowing a better use of the industry's expertise and a better functioning of the internal market. Indeed Directive 83/189/EEC[18] established information procedures in the field of technical regulations and standards, whereby the Commission can give a standardisation mandate to specialist bodies to undertake the development of technical standards themselves; and can contribute financially to this work. This would require, however, the establishment of a body to evaluate and select the areas to be covered, bridging the gap between research and development and the implemention of new technologies once they are fully established (see section 3.2 of the Annex).

29.- The Community can use the instruments available to it for support and implementation. It has already done so in the area of ATM wherever possible.

Under Article 129 relating to trans-European networks, the Community is able not only to adopt appropriate measures for ensuring the interoperability and interconnection of the national systems but also to provide significant financial support for implementing the ATM improvement strategies. To pave the way for this, the Commission has included ATM in its proposal for a Decision on guidelines for the development of the Trans-European Transport Network and, with the cooperation of experts, is drawing up a programme of projects to receive support for action in this area (see Appendix 3). In December 1994, at their meeting in Essen, the Heads of State and Government underlined the importance of the ATM sector.

Further, the availability of funds for cooperation with the Community's European neighbours, PHARE[19] and TACIS[20], make it possible to extend the Community's support to the whole of the area ideally to be covered by the ATM improvement strategies.

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18 OJ No L109/8, 26.4.1983

19 PHARE = Poland, Hungary Aid for the Restructuring for Technical Assistance to the Economy.

20 TACIS = Technical Assisance to the Commonwealth of Independant States

To be truly effective, however, these instruments should be used in a context of stronger cooperation, enabling comprehensive assessments to be made of the investment required; the funding capabilities of individual countries; and the progress made towards achieving joint objectives.

Article 130H, and subsequent articles, enable cooperation to take place between the Community, Member States and international organisations to assemble and implement a consistent research and development programme so that the best use is made of available resources in air traffic management. Indeed, the Commission has taken the initiative of coordinating, in close collaboration with its partners, the various ATM studies already included in the fourth Framework Programme through ECARDA[21]. It is essential to develop this, both to ensure that work is followed up and disseminated, and to build on this cooperation for still more ambitious programmes in future (see section 3.7 of the Annex; and Appendix 4).

In response to the need for greater coordination of RTD activities and policies, the Commission has also decided to set up Task Forces for specific subjects. The Task Forces should also provide support in transforming European scientific breakthroughs and technological achievements into industrial and commercial successes. The activities of two of the Task Forces, the Task Force on "New Generation Aircraft" and the Task Force on "Transport Intermodality", are relevant to ATM and support the objectives of this White Paper.

30. However, Community involvement in the field of ATM has certain limits, in particular because the preparation and monitoring of action in such a specialised field require particular expertise which, effectively, at present, is only available to national organisations and EUROCONTROL. Therefore, the Community would have to set up a new executive body to prepare the decisions to be taken and to follow up subsequent developments.

Such an operation, however, would not be easy to justify given the fact that other organisations are already working in the ATM field, and that the tasks of the new body would, to a large extent, coincide with those which are currently the responsibility of EUROCONTROL.

A solution could be to transform the EUROCONTROL Agency into a Community agency, but this could imply dismantling the organisation as such in order to keep only its means and resources for regulatory tasks.

Moreover, although such a Community approach would make it possible to deal with some of the problems facing the 15 Member States, it would not give the complete European dimension to the action required. The efficiency of Community air

21 ECARDA = European Coherent Approach for RTD in ATM

transport depends also on the quality of ATC services in non-Member States, because they have to be overflown, or because their airspace could be needed to absorb some traffic at peak times.

The Community could, certainly, use its powers under the Treaty to conclude agreements with its neighbours, but it is not at all clear if they would want this because such agreements could not necessarily guarantee them the participative role to which they have become accustomed in the organisations currently active in ATM.

Option 3: a broader European solution

31.- Considering the limitations of the previous option it seems preferable to look for a wider European framework than just the geographical area covered by the Member States of the Community. Working on the basis of such a broader coverage would be a far better way of improving the efficiency of European ATM - provided always that this approach does not have the effect of weakening the structures and mechanisms needed to achieve that objective. This would also provide for more flexibility, increasing the scope for subregional groupings to further integrate their airspace should they choose to do so.

Another major advantage of building the single ATM system on a wider multilateral organisation is that national governments might well find it easier to allow such an organisation to play a role in the military use of airspace[22], provided appropriate safeguards were foreseen and allow the States to retain in these cases the control of this use.

Given the existence of EUROCONTROL, it is obviously more sensible if that organisation were to take on part of the necessary regulatory role in Europe, becoming primarily responsible for airspace management and technical specifications.

This option would certainly require "reinventing" EUROCONTROL so as to give it greater political legitimacy, and invest it with powers as well as the necessary decision-taking, monitoring and support mechanisms to enable it to carry out its tasks properly. To do so calls for a careful examination[23] of a range of organisation models, covering the sub-functions listed in paragraph 24 to different degrees, and envisaging a range of possible decision-taking processes and control system. This exercise should identify new structures capable of meeting fully the requirements described earlier in this

22 Bearing in mind that there is no Community competence in this field.

23 Such an exercise is being carried out by the INSTAR Study, in close co-operation with the Commission.

paper; and of carrying out themselves, or supervising effectively the undertaking by others, all the various tasks discussed in the Annex. The EUROCONTROL Convention would then need to be revised accordingly to accomodate the model selected.[24]

32. The Community will itself have to take a position on the structure it prefers, so that it can present its own proposals in due course.

Obviously, it is the view of the Commission, that any solution will have to conform to the principal conclusions of this White Paper. In particular, there has to be a clear separation between the exercise of the regulatory and the operational functions, except for the operational aspects of Air Traffic Flow Management - and, if possible, of Air Space Management - which need to be performed centrally and should be regarded as part of the regulatory role of allocating available resources between their various users on a compulsory basis.

Although other operational tasks should remain decentralised at national level, this does not preclude joint ventures to perform them, where this is practicable and compatible with competition rules.

A central authority must be established to cover all the tasks except for the first one described in paragraph 24. This "new EUROCONTROL" should be given the powers and resources necessary to overcome the shortcomings described in paragraphs 13 to 18.

33. Moreover, since the Community already has competence in many of the fields for which the "new EUROCONTROL" would be responsible - see paragraphs 26 to 29 - and because the further development of Community competence would facilitate building a single ATM system, the Commission considers it essential that the Community becomes a full member of this organisation. This will allow the Community to exercise its competence and ensure that decisions were compatible with the policies of the Treaty and were taken in a more transparent and democratic way. The Community should, therefore, speak on all matters which fall within its sphere of competence, with sufficient voting weight to oppose any decision that would be contrary to its own interests. To do so, the positions taken by the Community will have been worked out beforehand in accordance with Community procedures so that all institutions can play their proper roles, and that the commitments regarding the consultation of interested parties, in particular the social partners, are met appropriately. Similarly, the positions of the Member States in matters where they are competent should be co-ordinated according to procedures

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24 EUROCONTROL itself is considering a draft new convention which would strenghten its organisational arrangements. In December 1995, however, the EUROCONTROL Standing Commission decided to postpone further consideration of this until this White Paper had been issued and debated.

which ensure close co-operation and the unity of the Community position in international fora. Finally, the Community would use the enforcement and incentive tools available to it in order to ensure that decisions are followed up and implemented in the territories of its Member States.

On this basis, and in the light of the work being done on the institutional arrangements, the Commission will develop a recommendation for negotiating directives in order to allow the Community to become a party to EUROCONTROL : obviously, this implies that the conditions described in paragraphs 31 to 33 are fully met.

VI. CONCLUSIONS

34.- Despite the notable achievements of the aeronautical community, and the quality of the strategies and programmes put forward, the present situation still does not guarantee that the Community will have the air traffic management system that would both meet the needs of users and satisfy its own policy objectives.

The Commission considers that, to attain those objectives, it is necessary to set up a system of air traffic management separating the regulatory from the operational functions and established at the widest possible European level, which is able to cut across national boundaries. Such a system must be based on the centralised exercise of regulatory functions together with certain operational tasks in the fields of Air Traffic Flow Management and Air Space Management, with the undertaking of other operational tasks remaining the responsibility of individual countries.

With the aim of making a positive contribution to the debate, and without prejudice to the exercise and development of Community competence required in this area, the Commission considers the third option developed in this White Paper as a pragmatic one, aimed at "re-inventing" EUROCONTROL which implies that the organisation must have the powers and mechanisms for decision-taking and monitoring needed to carry out its role with proper authority. The Community must become a member of the new EUROCONTROL with the weight it deserves and on terms which enable it to exercise its competence and allow its Institutions to perform the roles allocated to them by the Treaty. Accordingly, the Commission will make recommendations, in order to allow the Community to become a party to EUROCONTROL and ensure that the conditions for this option are fully met.

ANNEX

BUILDING A UNIFIED AIR TRAFFIC MANAGEMENT SYSTEM

Working towards unified Air Traffic Management System is a complex operation calling for continuous development simultaneously in several very different fields in order to achieve and maintain the following essential goals :

- a high level of safety;
- the protection of the environment;
- an increase in ATC capacity;
- effective control of costs;
- the most efficient use of available ATC capacity.

This Annex aims to analyse each of these goals, describe what is required in each case, and explain what needs to be done. In doing so, and without attempting to prejudge how the present institutional arrangements might be improved, the Annex pays particular attention to instances where they appear to be causing problems which hinder development.

1. A high level of safety

The main purpose of air traffic management systems is to ensure that aircraft can move about in safety, since it is established that, without air traffic control, the risk of mid-air collision would be intolerably high (see Appendix 1).

On the basis of the available indicators, it seems fair to say that this objective has been achieved in Europe: since the Zagreb collision in September 1976, there have been no further collisions between two airliners in controlled airspace over the continent. Furthermore, the total number of air misses has remained relatively stable since the 1980s in spite of the considerable increase in air traffic (see Appendix 2).

Nevertheless, given the expected growth in traffic, with a higher density of aircraft in an increasingly large proportion of Europe's airspace, even greater efforts must be made to maintain and, if possible, improve the efficiency of the European air traffic management system.

However, safety activities in the field of air traffic management will have to be carried out taking into account that they have to be integrated with the other areas of the civil aviation industry.

Accordingly, several measures must be considered without further delay.

1.1. The use of airborne collision avoidance systems (ACAS)

Aircraft must be equipped with a device which enables them to react in the event of loss of separation from other aircraft. The use of such equipment has been made obligatory in the United States in the wake of mid-air collisions which aroused great concern among the American public. Such a radical decision is being resisted in Europe, where controllers seem to fear that it would lead aircrews to take sudden avoidance action which might create even more dangerous situations. Nevertheless, all the experimental data show that the use of such equipment would improve safety in 95% of cases and create an additional risk in only 3% of cases. In the light of such clear evidence, the aviation community has decided to move swiftly to develop procedures whereby these additional risks can be eliminated and the use of anti-collision equipment can be made obligatory from January 2000. Some still consider that not enough simulation and tests have been carried out to validate this decision while others still consider the implementation date should be brought forward.

Comment : *The difficulty to arbitrate between various points of view demonstrates that the present arrangements lack of proper decision-making aids and of efficient decision-making mechanisms.*

1.2. The use of Short-Term Conflict Alert (STCA).

Appendix 1 describes how air traffic control is provided and specifies that the use of modern software allows, by integrating flight and radar datas, the calculation of predicted trajectories of aircraft and thus the anticipation of possible conflicts. Such systems, called Short-Term Conflict Alert (STCA), constitute a safeguard mechanism, which is rapidly becoming indispensable in areas of dense traffic. it has therefore been decided to implement them in all centres of the "core area" before the and of 1998.

This target date seems very distant, and might possibly be capable of being brought forward.

Comment : *In this case also, more far-reaching and determinate decisions would require proper decision-making aids and efficient decision-making mechanisms.*

1.3. Developing a safety policy

In view of their priority tasks, air traffic control organisations believe they have a responsibility to ensure that their services provide the highest possible level of safety. All down the line, each individual assumes complete responsibility for his or her role in this regard. "Quality control" in this context means examining how air misses are handled and action is taken when automatic alarm systems are triggered (see Appendix 1).

Since the air traffic controller's work involves constant trade-offs between safety and efficiency, to say nothing of customer satisfaction, a number of ATC bodies have realised that it is increasingly risky to allow such decisions to be made purely at the operational level, particularly in an environment where there is growing pressure from users on punctuality. They have concluded that what is needed is a genuine safety policy aimed at preventing incidents and accidents based on clear objectives and continuous surveillance -

such as was drawn up by the industry long ago for the purposes of quality control. This implies also setting up in each operational centre a specialised, independent unit with its own resources and the ability to gather information using not only traditional methods but also the incident processing and confidential reporting systems on which the Commission is currently working.

Comment : *the development of a comprehensive safety policy would require both a truly global vision and a clearer distinction between regulatory and service provision functions.*

1.4. <u>Other actions in the field of safety</u>

To deal with the ever-growing number of flights, new and more fully-automated technologies must be used operationally. The introduction of these new technologies will appreciably alter the human role in the actual control of movements in the air. It is important that sufficiently powerful tools be available to detect the new problems which human beings will have to face; to improve the recognition of the human factors involved in ATM; and to ensure that techniques similar to those already used for pilot training are integrated into the training of controllers.

Comment : *the definition and implementation of an ambitious work programme in the field of human factors will require reinforced co-operation in the research and technological development activities of all the parties involved and additional financial resources.*

2. *The Protection of the environment*

Environmentalists do not have a very positive image of aviation, and congestion and the resulting delays are regarded as further causes of pollution and nuisance. In fact, the situation is otherwise: for obvious safety reasons, the entire system of air traffic management, and in particular flow management, aims at keeping aircraft waiting on the ground with their engines stopped rather than waisting time in the air. Under these conditions, improving the flow of air traffic would have no direct effect upon the environment.

Nevertheless, it is generally accepted (see Appendixes 1 and 2) that the network of air routes in Europe adds 10% to the distances travelled and could be improved so as to reduce this excess by half, thus reducing proportionately the amount of fuel consumed and pollutants emitted.

Similarly, the improved use of airspace resulting from a reduction in vertical separations would make for optimum flight profiles, thus reducing consumption.

Accordingly the implementation of a Community strategy for improving the efficiency of air traffic management in Europe, in particular by making better use of airspace, reducing route lengths and avoiding unnecessary airborne holdings would make a significant contribution to sustainable mobility, beneficial also from an environmental point of view.

Comment : *the development of a consistent ATM policy requires a broader view to ensure consistency with policy aims in other fields.*

3. *Increasing ATC capacity*

As is emphasized by all airspace users, after meeting safety requirements, the first priority must be to increase the capacity of Europe's air traffic control system.

This is the simplest way to meet all the needs and to give everybody the freedom of movement and freedom of choice which are the foundations of any democratic society, if complex and controversial regulation for market access and access to airspace are to be avoided.

Moreover, within an air transport system based on a market economy and free market access, it is important to allow all operators to plan and operate their flights in accordance with their perception of demand.

To achieve these objectives, the aviation community acting within the framework of ECAC has adopted a harmonisation and integration strategy which aims to set up a unified air traffic management system. This is supported by the Commission to a significant extent and, indeed, by all the other interested parties, who have frequently stated their approval of the contribution of the EATCHIP and APATSI programmes towards implementing that strategy.

This chapter, therefore, considers what should be done to ensure the timely and effective implementation of these programmes.

3.1 Common objectives

Any programme for increasing capacity must be based on common operational objectives and a common implementation timetable to ensure that supply matches demand and to coordinate the expenditure involved. It would be an inefficient use of resources if the equipment introduced by a control organisation could not be used to maximum capacity because neighbouring organisations were working to a different timetable or had not matched their equipment to the needs of the system.

Although, the relevant work is indeed being done within the EATCHIP and CIP framework, a question mark hangs over these objectives since, at present, they constitute only voluntary commitments on the part of the ECAC States.

Up to now, goodwill and a commonality of interest have been sufficient to ensure that these commitments are honoured, as can be seen from the progress made in implementing the CIP. Consequently, there would seem to be no reason why these commitments should be made formal and mandatory: it is, moreover, difficult to oblige States to comply with objectives when their ability to do so depends on the availability of financial resources over which they do not have complete control.

Nevertheless, it would be useful to give these objectives a more formal status so as to enable the development of an investment policy stimulated by financial incentives from Community funds (networks, cohesion, cooperation) or any other available fund.

In this spirit, it might be necessary as well to consider setting up of a specialised fund, financed by ATC fees and managed by a central ATM authority.

Comment : *the present situation shows that decisions taken are insufficiently binding, are not followed up adequately, and cannot be adequately supported financially to ensure their proper implementation.*

3.2 Common procedures and specifications

One of the major reasons for the inefficiency of the present European ATC system is the difference in technical and operational specifications between the various ATC systems in use in Europe. This has led to the coexistence of mutually incompatible technical equipment with different levels of performance. The result is a major loss in overall ATC capacity and, probably, safety levels which differ from one system to another.

The EATCHIP programme has therefore tackled this problem, and EUROCONTROL has been asked to draw up the necessary common procedures and specifications, some of which will be given a mandatory character and known as "EUROCONTROL standards"[1].

The development of common procedures and technical specifications is indeed a *sine qua non* for providing Europe with a unified air traffic management system. In addition, the single market in ATM equipment and services cannot become a reality without common technical specifications. The European Parliament and the Council have, on a number of occasions, drawn attention to the importance of such procedures and specifications and have asked the Commission to do everything possible to facilitate the technical harmonisation work needed for this purpose.
Accordingly, on 19 July 1993, the Community adopted Directive 93/65/EEC on the definition and use of compatible technical specifications for the procurement of equipment and systems for air traffic management. This Directive makes "EUROCONTROL standards" mandatory at Community level.

But the work required to make this harmonisation and develop common procedures and requirements is heavy and costly. EUROCONTROL estimates its cost at 68 MECU for 1994 alone, and that figure will have to increase in coming years if the input required for the achievement of the Convergence and Implementation Programme (CIP) are to be available in due time. It is therefore necessary to make additional resources available to give this work a new impetus and allow the involvement of more stakeholders.

[1] "EUROCONTROL standard", which are mandatory technical specifications, are not to be confused with European standards. The latter are drawn up by European standardisation bodies, initially as voluntary technical specifications which may become mandatory in certain cases and are therefore processed through the Community legislative machinery.

Comment : *there is clearly a need for more financial support to implement and accelerate the standardisation work programme.*

Such financial support must, however, go hand in hand with a number of organisational or institutional reforms to make the action more effective.

One of the major weaknesses in the present process lies in the decision-making process which requires unanimity. Other more flexible procedures must therefore be considered.

Nor does the present decision-making process sufficiently involve the member countries of ECAC which are not members of EUROCONTROL and which therefore have only a moral commitment to the EATCHIP programme. Ways must therefore be found of enabling all the participating States to become genuinely committed to this programme.

Comment : *there appears to be a lack of effective decision-making mechanisms involving all ECAC partners.*

While recognising the value and the important contribution of the work undertaken within the EATCHIP framework, it is generally admitted that procedures and technical specifications are not being produced as rapidly as they should be. Apart from the decision-making aspects which hamper the process, other organisational difficulties also slow it down significantly.

The first difficulty is the length of time taken to identify common specifications, notably "EUROCONTROL standards", which are needed. Work on producing these common technical specifications and standards must get under way in good time so that the organisations concerned can have them when they need them. This applies not only to the results of research and development but also to the application of conventional technologies.

As regards equipment using conventional technology, which EUROCONTROL's current standardisation programme is largely concerned with, a structure must be set up to enable the early identification of technical matters which ought become the subject of "EUROCONTROL standards".

Since new technologies are of major importance for the system of the future because without them, it will be impossible to achieve a sufficient increase in the system's capacity, stronger links must be forged between R&D and the production of common specifications. This presupposes efficient decision-making procedures whereby the techniques and concepts to be introduced can be selected. Standardisation work would thus get under way in good time so that the necessary standards or specifications are available when the equipment is ready to be placed on the market. Having in mind the increasing integration between on-board and ground systems, any review of this area must now cover these two aspects in the perspective of a global system.

The second difficulty lies in the indiscriminate nature of standardisation work as done today. The real added value of EATCHIP is its ability to produce the common operational requirements, functional specifications and specifications for interoperability which are needed to ensure the harmonization and integration of Europe's ATC systems. These specifications, therefore, need contain only a limited amount of detail, leaving scope for additional equipment specifications to be drawn up by industry within the framework of the "new approach" for standardisation. Consequently, there must be closer cooperation between the various bodies involved in standardisation on the basis of their respective spheres of competence. For instance, in the case of questions relating to data processing or telecommunication systems, where existing standards can be reused or modified it might be more efficient to delegate most of the work to the European standardisation bodies.

The third difficulty arises from the fact that industry is not sufficiently involved. Its participation in the harmonisation work upstream of its normal activities would enable the other participants to benefit from its experience and thus develop practical solutions at lower cost. Moreover, since operational requirements have a significant influence on the market, it is only sensible that industry should be given an opportunity to express its opinion on a particular technology so that the maximum cost/benefit can be achieved. Suitable equipment could thus be made available more rapidly, and European industry would be in a better position to compete on the world market. From this viewpoint, European industry must organise itself so as to play its proper role in the technical harmonization process. The EUROCAE experience suggests that a pre-standardisation organisation should be set up, bringing together all the industries concerned.

The last difficulty arises from the fact that there are no means of ensuring that common specifications are complied with. There is little point in making them mandatory if there is no way of ensuring that they are actually applied. An efficient way of doing so might be to certify ATC equipment and systems. Although the interoperability of the these systems must be a top priority, other considerations such as the safety level of the service provided or its standard of performance might be treated in the same way.

Comment : *there appears to be an inefficient use of available resources suggesting a need for appropriate procedures and decision-making mechanisms to identify candidate subjects for standardisation; to allocate tasks among the various players according to their know-how; to prepare the corresponding standardisation mandate for specialised European standardisation bodies; and to ensure the effective implmentation of specifications and satndards through certification or labelling, as the case may be, for ATM equipments and systems.*

3.3. <u>VHF frequencies</u>

Air traffic control tasks cannot be carried out without radiotelephony (RT) communications between aircraft and control centres. In Europe, these communications use VHF (Very High Frequency) wavebands, with each controller and each sector being assigned a particular frequency with, sometimes, additional contingency frequencies.

Increasing air traffic control capacity while using the technology currently available (see Appendix 1) means increasing the number of sectors, and this in turn means making available a greater number of frequencies, since any given frequency can be assigned to two different sectors only if they are sufficiently far apart for there to be no possible confusion or mutual interference.

Given the performance of the equipment used, the transmission of a radio message requires a certain bandwidth, so that the VHF spectrum assigned to aviation by the International Telecommunication Union (ITU) is divided up into a limited number of usable frequencies. (This bandwidth is currently 25 kHz : ICAO is working to reduce it to 8.33 kHz, but it will be the end of the century before all airliners can be fitted with the necessary equipment.)

Any plans for a better use of airspace and any changes to its sectoral division mean that, at the same time, steps must be taken to reallocate frequencies. However, those States which have been allocated frequencies by the ITU tend to regard them as theirs by right, and thus resist any attempts at reallocation.

To deal with this problem, EUROCONTROL has set up an advisory committee, regarded as neutral and independent, to give its opinion on any reallocations. However because, as the committee's name indicates, its opinions are in no way binding, it would be necessary to give it real authority to make its decisions enforceable.

Comment : *there is clearly a lack of effective decision-making mechanisms with adequate enforcement authority to ensure the most efficient use of scarce resources, such as VHF frequencies..*

3.4 The use of airspace

Increasing the capacity of the air traffic control system means increasing the amount of airspace which may be used by non-military aircraft; and putting more aircraft into a given volume of airspace. In the following paragraphs, therefore, we shall consider how this can be done with the ATC techniques currently in use, given the performance of the available equipment (see Appendixes 1 and 2).

3.4.1 The use of military airspace

The simplest way to make available more airspace for civil aviation is to take some of the airspace reserved for the armed forces and convert it into non-military or mixed civil/military airspace - on the understanding that the military users of airspace must nevertheless be enabled to carry out their missions under acceptable conditions.

Accordingly, EUROCONTROL, within the framework of the EATCHIP programme, has developed the "flexible use of airspace" (FUA) concept which was adopted by ECAC Ministers at their meeting in Copenhagen in June 1994.

The idea is that non-military aircraft would be able to use some of the airspace hitherto reserved for the armed forces if the use of this airspace were subject to joint planning, taking account of both civilian and military needs. As with the management of air traffic flows (see COM(95)318 final), this concept will be implemented in three stages : (i) strategic planning, to ensure that civil aviation requirements are, as far as possible, taken into account in the planning of military activities, and that users are given sufficient notice of the additional routes to be made available and of the conditions under which they can be used; (ii) a pre-tactical phase, whereby these availabilities and conditions are confirmed or modified 24 hours in advance; and (iii) a tactical phase on the actual day of operation, when the objective is to maintain compatibility between the two activities and to take all appropriate measures to ensure sufficient flexibility to satisfy both civil and military requirements.

This concept is being implemented at national level, which means that where it proves impossible to satisfy each party's needs under acceptable conditions, arbitration is provided by each individual country, regardless of the difficulties that might be created for its neighbours.

It might therefore be questioned whether it would not be more efficient and equitable to envisage a collective system for managing the whole European airspace, taking account of the needs of all users, whether civilian or military, commercial or recreational, just as it has been possible to centralise the management of air traffic flows.

This could be done without affecting the sovereignty of individual countries as far as national security is concerned. The armed forces' need for airspace must indeed not be confused with the requirements of national defence : in the former case, what is required is a system which would provide sufficient access to airspace to enable the armed forces to carry out training or combat missions on a pre-set priority basis, whereas in the latter case it is sufficient to ensure that individual countries have all the information they need to object to any violation of their airspace, and that they have the right to re-establish complete sovereignty whenever necessary in serious crisis or conflict situations.

Comment : *the fact that allocation of airspace between military and civil use is effectively made at a national rather than international level shows a lack of a comprehensive view of Europe's airspace needs. It would be more satisfactory and efficient to manage the military/civil uses of Europe's airspace on a collective basis (taking as a model the management of air traffic flows), based on legal commitments which guarantee both an equitable access to the airspace for military needs and the safeguarding of the national defense requirements of individual countries.*

3.4.2 Reorganisation of routes and sectors

The routes network and the sectoral division of controlled airspace are among the recognised weak points of Europe's air traffic control system, especially when compared to the situation in the United States. It would appear that, in spite of all the planning work put in by EUROCONTROL and the ICAO, national frontiers and constraints both geopolitical and geoeconomic have had too great an influence on the organisation of air traffic control to enable the optimisation of the route network and the division of European airspace into control sectors.

Experts are calling for a wholesale review of these two aspects, taking into account the fact that, if the control system were operating at optimum efficiency, capacity in certain particularly crowded areas of Europe's airspace could be increased by anything from 20% to 40%.

Before this can be brought about, however, major studies and long and costly simulations must first be undertaken : accordingly, additional finance needs to be provided for the teams who are working on this problem. Such a scheme fits logically into the development of Trans-European Networks, and could be given significant assistance from the Community funds.

Finding appropriate solutions will, no doubt, mean having to adjudicate between divergent interests. Institutional arrangements should therefore be introduced not only to provide an overview of the optimisation process but also to enable the necessary judgements to be made at the right time and binding decisions to be taken.

Comment : *a comprehensive restructuring of the European airspace, on the basis of operational efficiency regardless of national boundaries, requires additional means and resources, objective assessment of the chosen solutions, and an effective decision-taking structure.*

3.4.3 Vertical separations

Above flight level 290, vertical separations are of 2,000 feet, although modern altimeters and the adoption of appropriate procedures would make it possible to reduce this separation to 1,000 feet, as is the case in the lower airspace.

Experts estimate that this would increase capacity by between 10% and 40%, depending on the region concerned and the complexity of the airspace involved.

However, before such a decision can be implemented, a number of prior steps must be taken : aircraft must be suitably equipped, and operational procedures must be altered. Moreover, if this measure is to have its maximum effect, there must be a new and more suitable division of the airspace into sectors - one that is compatible with controllers' workloads - and the number of controllers will probably have to be increased.

At present, the aviation community is divided as to the merits of such a change, and on how soon it should take place. The airspace users want it implemented as soon as possible since initial cost/benefit analyses indicate that it would lead to a considerable improvement in the service provided and have persuaded ECAC to adopt a target date of 2001 for implementation. On their side, airline pilots and air traffic controllers hold that insufficient tests and validation have taken place up to now to enable decision to be taken on reducing vertical separation. They stress that such a decision must be taken for the whole of Europe at once and must take due account of human factors effects.

Comment : *this case illustrates again a lack of proper decision-making aids and efficient decision-making mechanisms.*

3.4.4 Free flight

Another way of increasing capacity would be to use all the space available rather than to concentrate traffic within pre-set routes. This, moreover, would give users extreme flexibility. That is why the US authorities have recently set themselves the objective of making free flight possible.

Nevertheless, the ATC techniques used today (see Appendix 1) require aircraft to follow pre-set routes so that controllers know where their traffic is; consequently, free flight appears, at this stage, to be a particularly ambitious objective, and one difficult to achieve in the short term. As the work carried out in the United States seems to suggest, it would probably mean shifting some responsibility from the controller to the pilot, the latter being responsible for deciding on the simplest collision avoidance manoeuvres to take. More detailed thought will also have to be given to the development of traffic flow management techniques and their integration into air traffic control. It is thus probable that free flight will take some time to develop, and might even not be achievable in the core area of Europe if it is to be truly "free".

In the shorter term, however, there is nothing to prevent additional routes being created to offer users more direct itineraries; and to "dilute" the traffic by putting more aircraft into a given volume of airspace. Paradoxically, although the controller's task is, in some respects, facilitated by channelling traffic along air routes, it also makes it more complex, particularly where these routes intersect.

If the number of routes is to be increased they must become independent of ground-based navigational aids (navaids). Alternatively, there must be smaller lateral separations between airways than those in force today.

Although modern navigational equipment using conventional ground navaids enables pilots to follow any route they choose between reporting points without co-located navaids, they do not yet allow lateral separations to be reduced. The navigational precision required to achieve this objective (2 km) will become possible only if there is a denser network of DME stations or if satellite navigation systems come to be used as the principal means of navigation.

These considerations have given rise to the development of the concept of area navigation (RNAV), which is more realistic in the short term than the objective of free flight and is particularly advantageous for terminal areas where the dilution of traffic by multiple approach and departure patterns would compensate for the concentration of traffic which results from converging arrivals and departures.

It has already been decided that the first stage of implementing this concept - Basic Area Navigation (BRNAV) -, enabling new routes to be created, will begin on 1 January 1998. Not until the second stage, however, - Precision Area Navigation (PRNAV) - planned for 2005 will the most significant improvements take place, with a reduction in the longitudinal separations between routes or approach and departure tracks. Its implementation largely depends on the production and certification of more accurate navigation systems such as the GNSS.

Comment : *There is also a need for additional financial resources to speed up the standardisation work on precision area navigation (PRNAV) and to produce a European component of the future GNSS which can be used as a primary means of navigation.*

3.5 Developing the basic infrastructure

Developing ATC capacities means considerable expenditure within the framework of the national CIPs. According to the figures made available for the fourth ministerial meeting of ECAC in June 1994, an average of 1 200 MECU have been spent each year by the ECAC States since 1990 to improve their ATM infrastructures and it is generally admitted that the same amount of money needs to be invested each year at least up to 1998 in order to achieve the objectives of the ECAC en-route strategy.

While it is clearly a responsibility for the ECAC countries and in particular for their ATC service provides, to make the necessary investment, various Community funds can be used to help implement them, and a large number of applications for such assistance have already been submitted by the Member States and associate States.

To enable these funds to be used as efficiently as possible, it has been found necessary to draw up a strategy in terms of investment priorities at European level over the next five years, in order to make sure that they will be allocated to support these projects which would yield the best results in terms of improving capacity and safety.

Accordingly, the Commission and EUROCONTROL have launched a study aimed at identifying, the most beneficial technical changes which concluded that priority should be given to projects which improve :

- the continuity and quality of surveillance in Europe;
- the coverage and quality of the communication system;
- the interoperability of ATC systems and the automation of operational coordination.

In addition, steps must be taken to create a European component for the global navigation satellite system which, in January 1994, the Community decided to make one of its priorities.[2]

Detailed technical descriptions of the guidelines for such projects are given in Appendix 3.

In the course of 1995, the Commission has held a series of meetings with experts from the Member States to confirm and flesh out this strategy. It has invited industry representatives to attend these meetings so as to stimulate public/private sector partnership initiatives, as requested by the European Council.

Nevertheless, at this stage projects remain too "national" and it has not been possible to stimulate multinational co-operation for developing implementation projects. Even more, the lack of a comprehensive picture makes it difficult to evaluate the benefits in terms of the overall effect of implementing these various national projects, or the need for the financial aid requested. It is therefore not possible at this stage to evaluate if the requested funding is really necessary to increase capacity in areas where the local ATC service provider would not have the necessary resources to meet the targets agreed collectively.

Even if the outlook for feasability studies and large scale demonstration projects is more satisfactory, thanks in particular to the work carried out by EUROCONTROL in the framework of its STAR programme, there is a risk that the same shortcomings will arise at the implementation stage.

This situation confirms largely the statements in previous Section 3.1. about not only the need for more stringent common objectives, but also of financial tools to stimulate their achievement.

It appears also that as far as implementation of infrastructure is concerned, co-operation is not spontaneous. Since joint action can hardly be dictated, it should be encouraged thjough financial tools, whenever joint action would prove more cost-effective for the collectivity at large.

Comment : *While recognising that the provision of infrastructure is primarily a matter for individual countries, there is a need to reinforce consistency and co-operation between them. As far as this is concerned, there is a lack of decision-taking structures, and financial tools to support a real investment policy and stimulate co-operative action.*

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2 COM(94) 238 final, 14.6.1994.

3.6. Human resources

The ECAC Ministers, at their meeting in London in March 1992, asked for a report to be drawn up on the manpower requirements necessary to implement the remaining phases of the current ECAC strategy. Such an exercise is vital if common objectives are to be attained and consistency is to be achieved between different systems. Shortage of trained manpower in one area should not be allowed to affect the effectiveness in other areas, and thereby jeopardise the overall efficiency of the system.

3.6.1. Manpower planning

In response to the Ministers' request, EUROCONTROL formed a working group to study personnel issues, with a mandate to examine the availability, deployment and motivation of air traffic controllers. This group presented its first report in July 1993, according to which there will be a shortage of controllers in the ECAC area up until at least 1997. This will obviously have a direct impact on the capacity offered.

In the light of these findings the EATCHIP Project Board set up a Human Resource Team, which at its first meeting in March 1994 drew up a programme to promote work in the Human Resources field. The EATCHIP Human Resources Programme includes the harmonisation of national initiatives to ensure that there is, across the ECAC area, sufficient highly trained and motivated manpower. But if this co-operative and co-ordinated approach seems appropriate to overcome the shortage of qualified operational personnel, the lack of transparency in terms of the availability of accurate and up to date figures remain a major obstacle to progress in this field. Successful manpower planning depends on precise analyses of current resources and anticipated needs; and to this end ECAC partners should work closely together to make the necessary information available.

Comment : *It would also be advisable to set up appropriate procedures to ensure that common objectives are adopted and applied in the field of human resources. To do so there is a lack of decision-making aids and of efficient decision-making mechanisms.*

3.6.2. Training

Achieving a "seamless" ATM system in Europe requires a closer alignment of existing systems, and as such will have major implications for the recruitment, training, organisation and management of human resources. A study undertaken on behalf of the Commission in 1992 into 'Standards in ATC Schools of the EEC States'[3] highlights the major differences which currently exist between the recruitment and training procedures in the Member States.

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3 Study of standards in the ATC schools of EEC States. Dr. R. Baldwin - 31.12.1992.

The study concludes :

- States have widely different forms of training programmes, of varying duration. Within the training programmes there are formal courses at the training centres: these also differ widely in terms of specific courses, and the order and way in which they are combined to meet local needs.

- many ATC training staff lack recent operational experience which lowers the level of tuition;

- there is a great diversity in present educational entry requirements for trainees (school leaving age / post-university studies);

- few training centres are inspected by an outside body.

Harmonisation of recruitment and training procedures is therefore necessary to maintain and enhance the quality of performance and the level of safety. These objectives could probably be best obtained by establishing standards for common core training and a system of personnel licensing. Recourse to the latter would not only ensure high quality standards but also provide a highly trained mobile workforce.

Furthemore, the introduction of such provisions will require regular inspection and control by an independent outside body to ensure that standards are maintained.

Comment : *there is a lack of decision-making aids and of efficient decision-making structures to examine the possibility of developing systems for recruiting and licensing air traffic controllers, and for establishing procedures for harmonising training programmes and certifying training facilities.*

3.7. Development of new concepts and use of higher-performance technologies.

The forecast traffic growth over the next 15 years shows that long term solutions to current ATM problems require a huge increase of ATC capacity. Consequently, the RTD activities shall be targeted at enabling an Air Traffic Management System to be put into service from 2005 onwards with the capacity to meet projected demand well into the next century. This system would rely heavily on technology development to provide communication, navigation and surveillance functions with the required accuracy, reliability, availability and integrity, together with a significant level of automation of the air traffic control functions to enable controllers to handle the necessary volume of traffic safely. Such a system should provide an integrated approach to Air Traffic Management, including ATM at the airport, from pre-departure planning (strategic and tactical) through all flight and ground control phases to passenger disembarkation at the final destination.

A description of the views of the Commission on building the future European Air Traffic Management is given in Appendix 4.

A first limited (8 MECU) initiative of the Commission in this area was carried out in the context of the Transport Programme (Euret) of the 2nd Framework Programme (1987-91), with research into on ATM scenarios, Aeronautical Telecommunication Networks (ATN) and Controller Working Positions. In the 4th Framework Programme (1994-98), and through the Preparatory actions (APAS '94), considerably more resources (around 110 MECU) are being dedicated to ATM through the Transport, Industrial and Materials Technologies and Telematics Programmes, constituting a comprehensive approach to the development of the future system, which will be pursued in the 5th Framework Programme. The ATM and airport activities of the individual programmes have been developed within the framework of ECARDA [4] (European Coherent Approach to Research and Development in ATM), which in turn is designed to integrate with the activities of Eurocontrol, the European Space Agency (ESA) and the Member States.

For its part EUROCONTROL is managing huge programmes for testing and validating new concepts and tools, the STAR[5] and PHARE[6] Programmes, which amount to an average of 60 MECU per year. Being financed through ATC user charges, and users being reluctant to pay for long term research, this Programme is aiming primarely at short and medium term applied research. The work is largely done by the EUROCONTROL Experimental Center.

Finally several European countries have their own RTD activities, but, despite the attempts made in the framework of ECARDA, there is little knowledge on their precise content and cost. There seems also to be very little dissemination of their results.

All these efforts in progress should be improved by means of a continuous co-ordination process involving all interested parties; and enabling to advise, plan and monitor the RTD activities. This has been largely recognised by various studies sponsored by the Commission or EUROCONTROL (PRAISE)[7] to examine how to manage efficiently the RTD activities in Europe and facilitate the transition from research towards implementation

This should result in proposals for further RTD actions ; and in selection of the appropriate components and technologies to be put into operation, starting from the process of their validation through demonstrations, to their development by standardisation activities until their implementation as infrastructure projects.

Suggestion of themes, where further RTD activities are needed, should help building workprogrammes for all RTD actions, funded by the Community, European countries or any existing or future specialist organisation.

Where a component or technology is considered sufficiently mature to start its implementation, further initiatives should be taken to ensure that the previous RTD actions result in follow-up projects (see section 3.5 and appendix 3). The operational and pre-

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4 SEC (94) 1475 of 13.09.94

5 STAR : Studies, Test and Applied Research

6 PHARE : Programme for Harmonised ATM Research in EUROCONTROL

7 PRAISE : Preparation of an RTD programme in support of EATMS.

operational environment, which has been simulated in RTD activities, should be experimented in a full scale.

RTD activities could suggest a degree of technical development, requiring the drafting of standards before implementing the component or technology. The whole standardisation process starts, in most cases, from draft specifications resulting from a RTD activity. This is the third area where the co-ordination process should provide a consolidated view of those RTD activities which shall produce draft standards eligible for being proposed as contributions to the European and worldwide standardisation process.

Even so, in order to produce the benefits of this consolidated view in due time, Research and Technical Development activities need to be further increased and focused appropriately so that scarce financial and human resources are used as efficiently as possible. This implies that a real research policy is developed and that appropriate structures are put in place in order to select the most promising options, co-ordinate actions by the various participants and advise on timely standardisation and implementation so that benefits of new technologies can be reaped at the most appropriate time.

Comments : while recognising that the final decision in RTD activities remains the responsibility of individual countries, the European Community, and any specialist organisation, there is a need to reinforce consistency and co-operation between them.

4. Controlling the costs

While increased ATC capacity in Europe must produce improvements in the service provided and hence, by reducing delays, cost savings benefitting the public at large, there is also a price to be paid which is beginning to cause concern to air space users who, in Europe at least, have to foot the entire bill for the service provided, through user charges.

Taking into account the increasing importance of air transport in modern economies, it is essential that everything possible be done to keep these costs to a minimum, in order to enhance the competitiveness of the European States.

This presupposes a need both to review existing cost structures, and ways of reducing costs, but also to look at the scope for a more rational approach to technological choices and investment through the development of analytical cost-benefit tools adapted to the air traffic management sector.

It is in this spirit that this chapter looks at the various areas where action could favourably influence changes in the pattern of costs which are ultimately borne by the user.

4.1. The route network

Due to the controlling strategies used so far (see Appendix 1) aircraft are obliged to follow predetermined routes which make up the overall air route network.

A number of objective or subjective constraints (location of navaids, interconnection of arrival/departure trajectories, simplification of control tasks, bypassing of military areas, frontier mapping, etc) have brought about a situation where the experts believe that, on average, aircraft cover a distance 10% greater than the length of the most direct flight routes. This entails significant extra costs, estimated at 1 500 million ecus per year for Europe as a whole.

By contrast, however, the effects on costs of ATC constraints on flight profiles, whereby aircraft are obliged to observe flight levels which differ from the optimum profile, are only negligible.

Taking into account the necessary compromises associated with the reduction of distances travelled and the objective constraints referred to above, in particular the need to maximise the total capacity of the airspace, the experts consider that it would be possible to reduce by 4% the distances travelled in Europe, resulting in an annual saving of 600 million ECU (INSTAR study).

This is a further reason for revising the route network and introducing the concept of area navigation without delay (PRNAV).

Such a revision may nevertheless have significant implications for traffic orientation schemes, and hence an impact on the income of ATC service providers which should not be ignored. Accordingly any decision in this field will require difficult arbitration between many conflicting interests.

Comment : *a comprehensive restructuring of European airspace, on the basis of cost-efficiency, regardless of national boundaries, requires additional means and resources, an objective assessment of the chosen solutions; and an effective decision-taking structure.*

4.2. Service production costs.

Until very recently, air navigation services were provided by national administrations or by organisations of comparable status in the form of a public service, for which the first priority was to meet safety objectives. This has not always resulted in optimum cost efficiency, especially since, even when the service is charged to the users, charges are calculated so as to cover all the expenditures regardless of their amount.

Changes in thinking and pressure from users are beginning to call this situation into question, and it would be useful to examine whether there are ways of supporting and encouraging this new tendency. According to assessments made in the course of the INSTAR study, improved cost efficiency in the production of control services would enable savings to be made to the tune of 600 million ecus per year in Europe - that is, between 20 and 25% of the total costs.

4.2.1. Operation

Since 80% of costs are operating costs - 58% for staff expenditure and 22% for miscellaneous operating expenditure - it follows that the most significant improvements should be sought in the area of day-to-day management.

Against this background, certain people criticise the number of control centres in Europe and advocate regrouping them in a reduced number of larger centres so as to take advantage of economies of scale. At the same time, others argue that reducing the size of centres will contribute to improvements in the quality of human relations and the working environment, and hence productivity, which would cancel out any economies of scale of fewer, larger centres.

However that may be, comparisons carried out so far between centres do not show any link between costs and the size of centres.

It seems better, therefore, to rely on the ability of the executives and managers to achieve the best possible cost efficiency, taking into account their political and social environment and traditions. As mentioned in the INSTAR study, this should aim primarily at reducing the cost of support personnel and miscellaneous operating expenditure, as well as controllers' productivity.

Comment : *the present situation is caracterised by the lack of adequate cost control and the need to set up the appropriate institutional framework in which ATC providers would be encouraged to improve their efficiency and managerial skills.*

4.2.2. Investment

Accounting as it does for 20% of total costs, investment is also an area which merits more detailed examination, all the more so as more than a third is accounted for by interest payments on loans.

Public contracts for the purchase of supplies and services for the production of air navigation services are covered in the Community by Directives 93/36/EEC and 93/50/EEC, respectively, when the contracting party is the State; or by Directive 93/38 when it is an agency enjoying exclusive or special rights. In all cases, the technical specifications applicable to the contracts must comply with those laid down in Directive 93/65/EEC.

All in all, a suitable legal framework for ensuring transparency and normal competitive functioning in the award of contracts already seems to exist throughout Europe. Nevertheless, there is evidence of *de facto* partitioning of certain markets which is attributable, it would appear, to insufficient efforts to achieve standardisation in this sector.

Comment : *there is clearly a lack of standardisation in this area, which hinders the development of a free market for ATM equipment and services.*

While investors in the sector do not experience any major difficulties in obtaining financing, given the guarantees they are able to offer and the procedures for recovering costs, such financing is nevertheless expensive.

In point of fact, the interest burden included in the costs appears particularly heavy, which would seem to point to excessive borrowing for the financing of infrastructures, and hence insufficient own funds and insufficient reliance on self-financing.

Joint-venture partnerships between the public and private sectors should therefore be encouraged with a view to creating a more rational financial environment for the provision of air navigation services.

4.2.3. Cooperation/competition

Up to now the position has been that the provision of air navigation services constitutes a natural monopoly because, first, given the methods employed it is not possible for the same air space to be controlled by two different controllers; and, secondly, the related communication, navigation and surveillance services are also, by and large, provided by the same control service providers.

Against this background, the search for optimum economic efficiency should rely in a first instance on the promotion of international cooperation in order to gain advantage from every possible economy of scale: joint use of equipment (notably in the case of communications, navigation and surveillance); awarding combined contracts for supplies and services; establishing joint control centres, etc. To this end, the development of initiatives such as CEATS - the Nordic initiative - and numerous bilateral or multilateral cooperation agreements are particularly welcome and should be encouraged.

Nevertheless, in the longer run the quest for economic efficiency should also focus on the possibility of creating a more competitive environment which could stimulate still further cost reductions.

Indeed, the development of modern communication and navigation technologies, notably through the use of satellites, opens up the prospect of the emergence of a certain degree of competition in the provision of communication, navigation and surveillance services.

Private communications networks, which already enable passengers on board aircraft to call up people on the ground, could thus provide an alternative to the aeronautical mobile service provided they can comply with the levels of safety, reliability, availability and efficiency required for ATM. These same networks, linked to sufficiently accurate navigation facilities, could also offer an alternative (ADS[8]) to radar surveillance.

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8 Automated Dependant Surveillance

As for navigation facilities, both today's inertial navigation systems and the satellite navigation techniques of the near future also offer competitive alternatives to the navigational aids networks owned by the control service providers, if they can be certified as sole means navigational aids.

Apart from adequate economic viability, the development of these technical alternatives into competitive services also presupposes the opening-up of the market in terms of developing a set of neutral standards and certification procedures to enable potential new service providers to develop and market alternative services.

Comment : *separating regulatory/certification functions from operational ones would certainly facilitate new service providers to enter the market.*

As for the ATC services themselves as well as any other service which should continue to be provided on a monopoly bais, it would appear legitimate to apply to these services the rules normally used to control monopolies and to avoid abuses of dominant position. In accordance with the Treaty, it is a matter for the States concerned, under Community control, to fulfil this economic regulatory role in the framework of their traditions and their policies on the provision of public utility services. This could result in certain States opting

for fixed-term concession formulas, thus developing another form of competition among different service providers, whether public or private, as is already the case with regard to the provision of control services at certain UK airports.

4.3. Development of methods of economic analysis

As seen earlier, there is a price to be paid for the development of capacity and the reduction of inefficiencies, and the economic viability of certain technical options cannot be guaranteed in advance.

As seems to be the case with most current equipment plans and investment decisions in the field of ATM, the CIP is based on purely operational considerations. Little is known of the costs of implementing it; and the improvements that may be expected as a result have not been quantified.

There is a risk that this shortcoming will have even more serious consequences when it comes to choosing new concepts or deciding on the implementation of new technologies.

This has led the aeronautical community, under pressure from the users, to consider setting up economic indicators and cost-benefit analysis tools designed to rationalize the options.

This is a difficult exercise, and the degree of complexity involved depends on the geographical scale on which it is conducted as well as the technical nature of the projects under consideration. The same factors also affect the validity of the exercise, because of the interdependence of the various service providers, and the significant degree of interplay between the various elements making up the air traffic control system.

While analysis at local or national level can be envisaged in the case of projects of limited scope (notably with a view to assessing their financial viability), the correct determination of the economic viability of the majority of projects covered by the CIP calls for analysis on a European scale.

Moreover, simply carrying out such an analysis requires an ability to assess correctly the costs and benefits, and this is no simple matter in the case of a "product" that does not correspond to goods or services offered for sale at a specific price.

As far as costs are concerned, it will therefore be necessary to pay particular attention to defining the effects on the level of charges of the measures and investment planned, in order to quantify their impact.

In the case of benefits, while conventional methods can be used to assess the results as far as the community is concerned, especially in the area of safety, it will be necessary to develop new indicators that are relevant to this particular sector. Since the essential gains from any action must involve the reduction of delays and the satisfaction of demand, these indicators must be capable of quantifying, in a neutral and objective way, changes in ATC capacity, demand and delays.

As regards this last indicator, there is a well-known further problem due to the difficulty of isolating the causes of delays actually recorded in such a way as to separate those that are attributable to ATM from those linked to airport congestion or other operational causes. In order to tackle this question more effectively, the creation of a Central Office for Delay Analysis (CODA), as envisaged by EUROCONTROL and ECAC, is a necessary development.

Comment : *In this area there is a clear lack of decision-making aids. In particular, there is a need to :*

- *develop mathematical models for quantifying the impact of measures contained in the CIP in order to verify how far they will ensure user satisfaction in terms of capacity and quality of service to be provided; and*

- *conduct appropriate cost-benefit analyses for the optimisation of the choices of concept, technology or equipment, on the basis of a method of assessment suitably adapted to the ATM sector. This presupposes closer cooperation in the exchange of economic and technical data on projects as well as operating and processing costs and delay analysis.*

4.4. Cost recovery

Today, most European States recover their costs through charges.

These charges are in line with ICAO recommendations, in that they seek to recover only the costs incurred for the provision of air navigation services as such, excluding any profits or returns on the capital invested, except where loans are involved. Furthermore, they are calculated in terms of the distance travelled (i.e. the extent of the service actually provided) and the aircraft mass (i.e. its taxable capacity). In the area covered by the Multilateral

Agreement relating to Route Charges, which is operated by the EUROCONTROL Central Route Charges Office (CRCO) on behalf of the Contracting States, the distance flown is based on a standard route - the Most Frequently Flown Route (MFUR) between two airports. These routes are updated annually. Lastly, the charges are imposed on all users uniformly without discrimination or variation (although, in certain States, domestic services are not charged at the same rate as international services).

While this pricing policy has been well received and accepted by most users, it nevertheless produces many adverse effects :

- as seen in paragraph 4.2.2., it leads to an unfavourable cost structure by encouraging borrowing instead of the use of providers' own funds;

- it is not conducive to the promotion of public/private partnerships, since there is no return on the capital invested;

- it is hardly conducive to better cost efficiency, since costs will always be covered;

- it is not conducive to a commercial approach to the provision of air navigation services, since the user must pay for the cost of the service whatever its quality, over which, moreover, he has no control. This defect is further exacerbated by the MFUR method of calculating and redistributing the charge, since a State can receive a fee for flights which would have deliberately avoided its airspace, whereas the State which actually provided the service will receive nothing;

- it does not allow the pricing policy to be used as a tool for ensuring that better use is made of the available ATC capacity.

In order to alleviate these disadvantages,it should be considered whether, without calling into question the basic principles which underlie cost recovery - notably payment by the user of the service provided and non-discrimination - more flexibility could be introduced in the methods of calculating and redistributing charges.

Comment : *The cost recovery policy should be reformed so that :*

- *only the service actually provided is paid for (i.e. abandoning the flat-rate method);*
- *the fees are fixed in such a way as to include a certain margin of risk, whether in losses or profits. This will require safeguards to ensure that deficits from one year cannot be carried over for inclusion in the costs of subsequent years; and that increases in fees are subject to economic controls.*

Thought should also be given to the possible effects on demand of appropriate variation to the fees. Consideration of this aspect must, it would appear, form part and parcel of the other considerations suggested above with a view to achieving a better balance between supply and demand.

5. *Optimising the use of available ATC capacity*

As early as the 1970s the aeronautical community had recognised the need to manage air traffic demand in order to avoid overloads incompatible with the maintenance of ATC safety standards. The objective was essentially to keep on the ground aircraft which would otherwise have been in airspace where it would have been impossible to handle them safely at the time. A number of national Air Traffic Flow Management (ATFM) Units were created to manage this process.

The crisis at the end of the 1980s highlighted the strategic importance of ATFM and the need to carry it out on a European scale in order to benefit from an overall view and make efficient use of ATC capacity. This resulted in the agreement to create the Central Flow Management Unit (CFMU) managed by EUROCONTROL and operating on behalf of all 33 States of ECAC - that is, most countries in Europe.

ATFM has become an essential aspect of ATM because it is economically unjustifiable to provide ATC capacity at a level to cope with the highest traffic peaks. It is therefore necessary to live with an acceptable level of undercapacity. The ATFM mechanisms are also needed to deal with crisis situations when capacity is reduced for unplanned reasons such as strikes, equipment failures, airspace closure, etc.

In its Communication on Congestion and Crises in ATM, the Commission has described in detail the mechanisms used to manage air traffic flows in Europe.

These mechanisms depend mainly on voluntary action and the goodwill of those involved. The latter consider that the mechanisms are, in general, satisfactory; and have great hopes that the full implementation of the CFMU will improve their operation and efficiency.

The Commission has nevertheless concluded that it would be useful to consider whether introducing a minimum degree of obligation, or indeed incentive, to promote further co-operation depending on the situation, could strengthen and accelerate that improvement; and suggested the following areas for further action.

5.1. Planning

The main weakness of the existing planning mechanisms for ATFM is the lack of certainty. Whilst goodwill is not in question, the insistence of each participant on retaining as much flexibility as possible hinders serious advance planning. The result is uncertainty and increased real-time activity as operators try to negotiate improved slots or alternative routes.

Changing this situation would involve all participants, and would require great efforts to better evaluate and balance demand and capacity through improved co-operative mechanisms.

5.2. Capacity

It would be desirable to develop a standard method and analysis tools for determining ATC sector capacity, and to establish procedures for common capacity planning. The results of such planning should be binding - except in conditions of force majeur - and should be used by airspace users and airports to better plan and organise their own activities.

This work should be co-ordinated by the CFMU, which could indeed be given sufficient authority to take decisive actions.

5.3. Demand

If it is recognised that aircraft operators must have the flexibility to meet market requirements, it is also accepted that a minimum of realism and self control should be introduced in the planning of their activities if passengers are to receive the service that they deserve.

To achieve this goal, planning by both airspace users and airports should give more consideration to ATC restrictions. This would require that they are allowed, consistent with anti-trust law, to meet and co-ordinate in order to make better use of the available capacity. Pressure to co-operate in the process might be applied by requiring airports and aircraft operators to publish punctuality figures so that passengers could see which are planning realistically and which are not.

A detailed analysis of the possibility of integrating airport slot allocation mechanisms and the air traffic flow management process should be carried out.

5.4. Priority rules

The underlying priority principle in ATFM is the "first come - first served" queue. It would be useful to consider for each phase of ATFM operations what priority rules would lead to the most efficient use of the available capacity and what compromises might be necessary in order to make such rules acceptable to all concerned.

In so doing, consideration should also be given to the need for the CFMU to be provided with a proper legal basis for its work. This must give authority to its decisions whilst at the same time defining the framework within which it is empowered to act.

5.5. Management of crisis situations.

Although it is accepted that the mechanism put into place by EUROCONTROL should be left to demonstrate its effectiveness, it would also benefit from additional political support.

The examination of priority rules referred to above should also include the consideration of special rules which might be invoked in crisis situations. These would have to be supported by a decision making mechanism for authorising the CFMU to apply the modified rule in any given circumstances.

It would be useful for planning purposes to establish a common standard of minimum service levels to be provided in case of industrial action, particularly if the standard was defined in such a way as to limit the interference to international overflying traffic.

The difficulty of obtaining agreement between Unions and Management in this area is not underestimated, but it is considered that the potential benefits are such as to make the effort worthwhile.

Comment : *In its Communication on congestion and crisis the Commission concluded that a number of actions were needed in this area, but reserved its position on the most appropriate institutional arrangements to manage air traffic flows.*
It is nevertheless clear, from the analysis developed in the Commission's Communication, that Europe needs an appropriate body, based on the CFMU, empowered with enough means and authority to plan air traffic flows, predetermine ATC capacities to be provided and, if required, allocate available capacity according to rules established in advance.

AIR TRAFFIC CONTROL PRACTICE

Air traffic control is a service provided to airspace users, with the objective of keeping them a safe distance apart.

In sectors with heavy public air traffic, this service is a sine qua non for the development of air transport. In this respect, it is very different from other traffic management services which are optional (apart from in certain shipping lanes) and are designed, above all, to optimize traffic flow or fleet management.

After the first mid-air collision (in Vienna in 1910), there was a clearly perceived need for rules on air traffic so that aircraft would apply common rules to avoid one another. With the advent of blind flight and of ever faster aircraft, these were no longer enough and pilots could no longer prevent mid-air collisions on their own. They then had to turn to outside help, from air traffic controllers.

Of course, the sky seems vast and empty. But according to a study in the USA, without air traffic control the risk of mid-air collisions in densely crowed airspace, such as over Western Europe, would be 100 times higher. In other words, the probability of an accident would be intolerable.

What is controlled?

Virtually all aircraft carrying members of the public and operating in conditions making visual flight impossible need an ATC service. To achieve this, the aircraft must be equipped for instrument flight, with an indication of their altitude and position and the possibility of establishing radio contact with the control authorities at any time. Similarly, the crew must hold IFR (instrument flight rules) qualifications. Finally, for each flight users must lodge a flight plan informing the control authorities of their intentions (route, flight levels, departure and arrival times, time of passing certain landmarks, location devices, survival kit, etc.). This is a sort of contract which must be submitted to all the air traffic authorities which need to know of the flight.

Military aircraft are also monitored, despite their very different performance and roles. They fly very high or very low and perform interception operations, provide support for troops on the ground or carry out bombing missions. In order to do so, they must have training grounds, which they cannot share with other types of traffic for safety reasons. They interfere with general air traffic only when they fly between their bases and these restricted areas. Coordination is therefore needed to ensure flight safety. In most countries, military flights are controlled by military controllers who provide the requisite coordination with their colleagues in the civil sector. Some countries with very heavy civil and military air traffic have preferred to entrust one and the same control body with this phase of military flights too, as in Germany and the USA.

Where

Wherever the nature of the flights (instrument flights, commercial flights, high-speed flights, etc.) and traffic density dictate. Accordingly, in Western Europe all the upper airspace (over 6 000 m) is controlled, plus the airways (rectangular corridors 18 km wide and at an altitude of between 1 500 m and 6 000 m protecting an air route in the lower airspace), terminal control areas in the vicinity of airports containing standard take-off and landing paths between the runways and the air routes (between 900 m altitude or 300 m above ground level and a sufficient altitude to allow the necessary operations) and airport control areas linking the terminal control areas to the ground around major airports. No control service is provided outside these areas, particularly close to the ground, where the aircraft which need ATC services rarely fly, leaving this space free for light aircraft. The same applies outside the airways, since in Europe this space is often occupied by military areas reserved for operational training for the armed forces.

Generally, ATC services are provided for aircraft following predetermined routes, i.e. on the network of airways which cross the airspace. Consequently, aircraft are not free to take the shortest route, but must follow these paths. It is generally acknowledged that in Europe this adds, on average, 10% to the distances flown. However, it seems difficult to overcome this constraint with the current control technology, since air traffic controllers need to position their traffic on such routes in order to do their job.

In regions with less dense traffic, there are vast uncontrolled areas where users are nevertheless provided with a flight information service (weather reports, traffic in the vicinity, distress alert).

How?

Air traffic control consists of keeping aircraft a safe distance apart, based on a knowledge of the position of the aircraft in a given sector. Consequently, the separation between aircraft will depend on the precision with which the position of the aircraft is known, which, in turn, depends on the instruments used to determine the position and speed of the aircraft en route or approaching. In accordance with the precision of the altimeters, the standard vertical separation is 300 m up to an altitude of 9 000 m and 600 m above that. The horizontal separation can vary between 225 km in the case of aircraft on the same route if their position is known only from their own reports (procedural control) and 5.5 km in the case of aircraft approaching under radar control. The separation between aircraft en route under radar control is 9 km, although this must be increased where the performance of the radar equipment is inadequate, as it still is in certain parts of Europe.

If two aircraft come closer together than the standard separation, this is known as an "air miss". Pilots and air traffic controllers must report such incidents. Analysis of air misses gives an idea of the safety standards provided by the system and allows the requisite corrective measures. In some ATC centres this is backed up by automatic conflict detection methods, where the controllers are assisted by computer.

To perform this task, all aircraft in a given control sector are placed under the responsibility of an air movements team (one principal controller and two assistants) who must take control of any possible interference between aircraft. Taking account of the pressure of work which this entails and of the control aids available today, it is universally accepted that not more than 15 to 20 aircraft may be in the same sector at the same time, depending on the complexity of the traffic handled (number of air route crossings, configuration of the landing/take-off paths, transfer to and from sectors alongside, above or below, etc.). Airspace capacity therefore depends on the number of sectors into which the airspace can be divided. However, there is a limit since if the sectors are too small the aircraft will not stay in them long enough for potential conflicts to be detected and resolved before they arise. At the same time, the workload for negotiating transfers from one sector to the next will be heavier and the sectors' unit capacity lower. A compromise must therefore be struck between the size and number of sectors. This is what determines airspace capacity.

The sectors are brought together under control centres, which provide a means of combining them in line with variations in demand and of adapting supply to demand. Today, there are 42 en-route control centres in Western Europe to control the upper airspace, air routes and terminal control areas. In the USA, 21 en-route control centres, backed up by 189 terminal radar control (TRACON) facilities, handle six times as much traffic.

To avoid overloading the sectors, and the potential consequences for flight safety, air traffic flow management (ATFM) mechanisms have gradually been developed to detect any such risks of congestion in advance and to ground any aircraft which would have had to fly in a saturated sector. The development of these mechanisms and their growing use in air traffic management were described in the Commission communication on congestion and crisis in air traffic (COM(95)318 final of 5 July 1995).

By whom?

The air traffic controllers are responsible for maintaining the separations. In order to do so, they must form a mental image of the situation in their sector at any time in order to detect potential conflicts, devise solutions and give the pilots the necessary instructions: change flight level, slow down/accelerate, wait, change flight path, etc. To help them in their work, air traffic controllers use small strips of paper, each representing one aircraft and giving details of the flights. These are set out on a console representing their relative positions. Virtually everywhere in Europe ATC controllers also have a radar image which gives them another two-dimensional picture of air traffic. They communicate by radio with the aircraft and by telephone with the other controllers with whom they must coordinate transfers.

Air traffic controllers perform a complex task which is more like an art than a traditional repetitive job. It requires a special predisposition and a very high level of training. These features combined with the fact that the slightest lapse has immediate consequences for the safety of hundreds of passengers mark this out as a clearly distinct profession with its own rites and scales of values.

Almost everywhere the controllers and the staff responsible for the equipment (electronics engineers) and for various operational tasks (particularly flight plan processing) are employed by the national administrations or State-owned private agencies. This State involvement is due to the Chicago Convention which makes the States responsible for safety in their airspace. But it is also attributable to the heavy civil and criminal liability associated with this activity.

Virtually throughout the world ATC services are funded by charges levied on the direct users. One notable exception is the USA where all expenditure on civil aviation safety is funded from taxes and a charge levied on the end users, i.e. air passengers.

With what?

As mentioned earlier, air traffic control requires special equipment.

First, means of communication between the ground and the aircraft are needed to transmit messages about the aircraft's position and ATC instructions. The ATC authorities have established a private mobile air-to-ground communications service, principally in the VHF (Very High Frequency) band, but also in the HF (High Frequency) band for long-range communications. Today there are also plans to use satellite communications.

Ground-to-ground links are also needed to transmit flight plans and allow coordination between different controllers. Another private network has been set up for this purpose, using subsystems leased from the telecommunications operators to provide a fixed service linking all ATC centres, airports and main users.

Navigational aids are also needed so that pilots know the aircraft's position at all times and can inform the ATC authorities when necessary. These can take the form of stand-alone on-board equipment, such as inertial guidance systems and Doppler radar, or of navigational aids on the ground using different frequency ranges, depending on the ranges to be covered, to transmit signals from which aircraft can calculate their position: VHF omnidirectional radio range stations (VOR), distance measuring equipment (DME), non-directional beacons (NDB), instrument landing systems (ILS), the LORAN and OMEGA long-range navigation systems and, increasingly coming into consideration, the GPS and GLONASS satellite systems. Consequently, to provide the navigation service, the air traffic authorities have been setting up networks of navigational aids, some denser than others.

Air traffic controllers also need to know the position of aircraft under their responsibility as well as possible. The more precise and frequently updated this information, the more the controller can reduce the separation. For this reason, position reports from aircraft have been replaced by a stand-alone radar system which gives a comprehensive picture updated after each turn of the antenna (every five to ten seconds). There are different types of radar, depending on the phase of the flight. The latest radar technology can identify the position, altitude and call sign of aircraft. Soon it will be possible to use these radar waves to transmit other data between the ground and the air (S mode radar).

At the same time satellite technology is opening up the possibility of developing a rival on-board Automated Dependent Surveillance (ADS) system, which would automatically transmit the aircraft's position to the ground at all times.

All the information and resources required by air traffic controllers are brought together at the control consoles. Telephones, microphones, video screens, strip boards, etc. are all found there in the most ergonomic, interactive configuration possible in order to lighten the air traffic controllers' workload and enable them to handle more aircraft at the same time. To achieve this, computers have been introduced en masse in control centres. To date, however, their role has remained limited to processing and displaying information. In the most modern centres, they can also alert controllers a few minutes before a collision risk. But they are not yet capable of proposing a strategy for resolving such conflicts.

Within which institutional framework?

According to the Chicago Convention adopted at the end of 1944 to lay the basis for a global system of international air transport and its basic principle that States have full sovereignty over their own airspace, it is their responsibility to provide air traffic services and to mobilize the necessary resources for this purpose.

At the same time, the International Civil Aviation Organization (ICAO) was set up to define and adopt the common rules needed to make the system interoperable so that any one aircraft could travel anywhere in the world. This organization is also responsible for ensuring that the services correspond as closely as possible to the needs of the users. It may, consequently, give certain States responsibility for supplying such services to aircraft crossing international waters.

It is nevertheless a relatively flexible framework, within which it is even possible to notify differences from the common standards, while the undertakings given in connection with the satisfaction of users' needs are not legally binding.

Each State is free to decide the level of service to be provided and the means to be employed for this purpose, with the result that the technology used and the results achieved vary tremendously from one country to another, making the overall system less efficient than it should be.

To overcome this problem, if only in part, groups of States have felt the need to cooperate more closely at regional level and, in some cases, to consider actually integrating their national services. It is the reason why EUROCONTROL was up in 1960 by an international convention, to provide air traffic control for the entire upper airspace of its Member States. This, however, represented too great a transfer of sovereignty for some of the first Member States: even before the Convention entered into force, France and the United Kingdom reclaimed control of the whole of their own airspace, and Germany later largely followed suit. Thus EUROCONTROL today, via its control centre at Maastricht, provides air traffic control only for the airspace above the Benelux countries and Northern Germany - and then only within the framework of specific agreements between the organization and each of the States concerned.

By way of compensation, EUROCONTROL was given a greater coordinating role in planning and research, and its Convention was supplemented by a multilateral agreement under which it was given responsibility for collecting route charges.*

In parallel with these developments, and in view of the lessons learned from over-ambitious attempts at integration, the ICAO reinforced the existing mechanisms for cooperation at regional level by setting up a more permanent structure than the regional meetings. This was the EANPG,[1] which was able to meet once or twice a year if need be and to work more or less continuously on updating and monitoring the Regional Air Navigation Plan.

* Today, EUROCONTROL has 19 Member States (the States of the European Union except Finland, Italy and Spain, plus Cyprus, Hungary, Malta, Norway, Slovenia, Switzerland and Turkey). The multilateral agreement on route charges covers these same countries plus Spain.

1 European Air Navigation Planning Group.

ATM : A QUANTITATIVE DESCRIPTION.

1. INTRODUCTION

1.1. Scope of the annex

This annex looks at the technical and operational aspects of the current Air Traffic Management (ATM) system in Europe, covering all the national organisations that provide air traffic services (ATS) to airspace users (aircraft operators), in accordance with suitable rules and standards, for the safe, orderly and efficient movement of aircraft in the air and on the ground.

ATS are divided into specific services :
- Air Traffic Control Service (ATC) ; it aims at preventing collisions between aircraft or between aircraft and obstructions on the manoeuvring area ; and at expediting and maintaining an orderly flow of air traffic ;
- Flight Information Service (FIS) ; it provides advice and information useful for the safe and efficient conduct of flights ;
- Alerting Service ; it notifies appropriate organisations regarding aircraft in need of search and rescue ; and assist such organisation.

Annex 1 explained that ATC :

- are the services provided by Air Traffic Control Centers to control the movements of aircraft both on the ground and in the air by the continuous tracking and coordination of moving aircraft to keep abreast of their respective positions in order to ensure safe separation and passage between airports;

- are delivered to airspace users in three different ways: at the airport itself, and during landing and take-off (airport control); within the terminal airspace surrounding an airport (approach control); and in the airspace between two terminal areas (en-route control);

- are carried out by air traffic controllers following specific procedures with the help of facilities and equipment capable of supporting this work.

This Annex concentrates primarily on the en-route aspect of European air traffic management, and ATC most of all, aiming to describe it in quantitative terms to complement the more qualitative description in Annex 1.

1.2. Methodological approach

The Annex first describes the way in which air traffic services are provided in Western Europe (supply analysis); and then looks at precisely how users need these services (demand analysis). Finally, it reviews the interaction between supply and demand, and considers the quality of service that results. Wherever possible this description is supported by figures, to illustrate both trends over past years and correlations between variables; and references to recent studies.

With this in mind, the Annex consists of three chapters:

- Chapter 1 looks at each of the three components of the ATM system, airspace, technical facilities and staff;

- Chapter 2 analyses the requirements of airspace users;

- Chapter 3 looks at the actual performance of the system as it works in practice in terms of matching the demand for, and the supply of, Air Traffic Services.

Air traffic management consists of three main activities. Two of these concern the supply of services (airspace management and air traffic control). And, thirdly, flow management aims to match supply to demand:

- airspace management means the design of the structures (in the form of sectors and routes) that enable airspace to be used according to specific procedures;

- air traffic control involves the technological and human resources necessary for the supervision of aircraft;

- air traffic flow management improves the use of airspace by identifying and resolving capacity problems when demand exceeds supply.

Finally, it should be borne in mind throughout that this survey looks at airspace management in Europe generally, rather than at the area covered by the EU.

2.. HOW EUROPEAN AIR TRAFFIC SERVICES ARE PROVIDED

2.1. The structure of air traffic management

The planning and operation of Air Traffic Management in Europe is carried out on a national basis, through the public sector, with varying degrees of coordination via organisations such as EUROCONTROL (European Organisation for the Safety of the Air Navigation), ICAO (International Civil Aviation Organisation - European region) and the European Civil Aviation Conference (ECAC).

Three factors explain why Air Traffic Services are undertaken on a national basis and by public sector bodies:

- the birth of air traffic control during World War II as a means of identifying and locating military aircraft. Its subsequent extension to civilian air services was influenced by the original purpose of securing the defence of national airspace against hostile aircraft;

- the Chicago Convention of 1944, which enshrined the principle of national control over the use of sovereign airspace ;

- the perceived importance of such services, together with airlines' own services, as vital assets influencing the development of national economies.

This national approach to ATC in Europe has, as a result, led to the development of an institutional and organisational structure where responsibility for the provision ~~of~~ Air Traffic Services tends to be shared between three different bodies within national administrations:

- the government level, with the Ministry of Transport or Communications concerned with policy decisions;

- the management level, for which responsibility lies with the Civil Aviation Administration or Authority (CAA);

- the operational level, where the actual provision of ATC services is usually the responsibility of Air Navigation Services (ANS) organisations.

Detailed arrangements may vary between different countries - for instance, the ANS organisation may itself be a part of the CAA - but, generally, the three levels will follow this pattern:

- the government level will be concerned with supervision of the system overall, and future investment policies;

- the management level will be responsible for ensuring the integrity of safety, setting standards , defining strategies and future planning;

- the operational level will provide the services to airspace users, develop the planning of future service provision and organise revenue collection in the form of fees paid by airspace users for Air Traffic Services.

The need for an international approach to aviation matters led to the setting up of various organisations for the development and application of common regulations and operating procedures. ICAO was formed in 1944 as an international body for the purpose of developing international standards and conventions for International Civil Aviation and Air Traffic Control, in conjunction with industry bodies and national administrations. Within Europe, ECAC was established in 1955 as an inter-governmental organisation, supervised at Ministerial level, to oversee the European system and propose and coordinate improvements in air transport. In the 1960s another inter-governmental organisation, EUROCONTROL, was formed which was originally intended to develop means of providing Upper Airspace Control Services across all its Member States on a unified basis. In practice this was only achieved over a relatively limited area - Benelux and North Germany. EUROCONTROL's mandate was later extended to include the collection of route charges, the development of standards, research and advisory services and the management of air traffic flows at a European level.

The respective roles and responsibilities of the various national and international bodies in terms of the three levels of ATC management functions - government, management and operations - are summarised in the following table:

Table 2.1. - Current roles and responsibilities

Level - Role	ENTITY					
	National			International		
	Min	CAA	ANS	ECAC	ICAO	Eur
Governing						
- Supervision of the system	■			●		
- Investment policy	■			●		
- Standards setting	■	●	●		■	■
Managing						
- Safety oversight		■				
- Investment planning		■	●	●		
Operating						
- Services provision			■			●/■*
- Services planning			■			●/■*
- Revenue collection			■		●	■

Legend:

■ responsible
● advisor
Min = Ministry
Eur = EUROCONTROL

* Eurocontrol has responsability for service provision and service planning for the Maastricht Centre and the Central Flow Management Unit (CFMU) ; and an advisory role in other flields.

2.2. The complexity of airspace structure

Basic division of airspace is into :
- controlled airspace, and/or
- uncontrolled airspace.

By international agreement, airspace structures are set up in seven different airspace control classes around fixed air routes and control zones. The service provided to aircrafts flying on instruments (IFR) and to aircraft flying visually (VFR), reflects the requirements of airspace users and the density of air traffic.

Air Space Management consists of two separate activities:

- Ground-based controllers control aircraft within the "sectors" of airspace for which they are responsible. These sectors make up airspace structure;

- aircraft are piloted by their crews along "airways" which form the airspace network.

The current structure of European airspace structure is determined, in the first place, by the boundaries of each country's airspace. Other determining factors are operational and technical, mainly to do with the performance of communications and navigation aids. At operating level, Air Traffic Services infrastructure is managed in the first place by Area Control Centres (ACCs), each of which is responsible for supervising the use of the airspace within a territorial area (Flight Information Region (FIR)). The airspace within each FIR is, in turn, divided into sectors in ways that best suit the process of controlling aircraft within it.. A sector is notionally the volume of airspace that can be controlled by a single controller; but in practice some sectors are amalgamated with others where this makes sense in terms of traffic loads.

As well as being separated horizontally, airspace is divided vertically, generally being divided into Upper and Lower Airspace at a specified altitude level:

- below this level is the Flight Information Region (FIR), where flights are controlled in the climb and descent phases;

- above this level is the Upper Information Region (UIR), where flights are controlled at their cruising altitude.

Most FIRs and UIRs share the same ACC but, in some cases, countries have established separate Upper Air Centres (UAC).

Two countries, the UK and Portugal, operate Oceanic Area Control Centres (OACC) to provide air traffic control over the eastern part of the North Atlantic.

Areas around principal airports may need separate systems for co-ordinating flights to control arriving and departing flights.

The current structure of European airspace is summarised in table 2.2. For each country it shows:

- the area covered by the Flight Information Region;

- the flight level chosen as the boundary between the FIR and the UIR;

- the maximum number of 'single' sectors that can be operated simultaneously by each ACC.

Table 2.2. - Airspace structure in 1995

Country	*Surface FIR (km^2)*	*Separation FIR/UIR*	*No of ATC Units*		*No of Sectors*	
			ACC	*UAC*	*En-route*	*APP*
Austria	84000	FL 245	1	-	14	6
Belgium	30500	FL 195	1	-	4	2
Denmark	n.a.	FL 245	1	-	9	3
Finland	n.a.	FL 245	2	-	4	-
France	768600	FL 195	6 [1]	-	74	6
Germany	297600	FL 245	6 [1]	1	61	12
Greece	277200	FL 245	3 [1]	-	9	2
Ireland	168000	FL 245	2	-	9	3
Italy	n.a.	FL 245	4	-	28	9 [2]
Luxembourg	-	FL 245	-	-	-	-
Netherlands	34000	FL 195	1	-	6	3
Portugal	276000	FL 245	1	-	5	2
Spain	621875	FL 245	5 [1]	-	32	16
Sweden	n.a.	FL 245	3	-	19	8
United Kingdom	575000	FL 245	3	-	41	16
Maastricht UAC	n.a.	-	-	1	7	-

1 - with the addition of one separate Approach Units
2 - 5 sectors play en-route + APP role

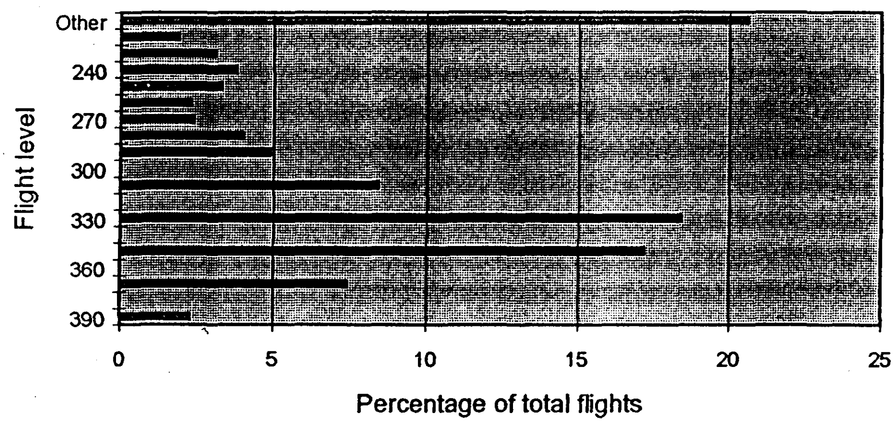
Source: EUROCONTROL - CIP - Status Report 1995

2.3. **The configuration of the airspace network**

The European airspace structure consists of a network of fixed routes. These routes were originally aligned according to the siting of navigational aids - usually close to airports. This means that routes normally follow dog-leg paths, and cross one another frequently at points where it is particularly important to avoid conflicts. (This pattern may vary, but only to a degree when airspace normally reserved for military use becomes temporarily available for civil use, allowing some more direct routeing.) Because the route network is defined in two dimensions only, aircraft flying along the same route on conflicting courses are assigned different flight levels. Flight levels are spaced 1000 feet apart up to FL 290 (2900 feet), above which the spacing is 2000 feet. Even-numbered flight levels above FL 300 are not, therefore, used at present.

Table 2.1. gives an indication of the present use of flight levels based on airlines' requests in July 1990 (EUROCONTROL figures) ; experimental studies have demonstrated that the best cruise level for a flight of 500 NM in terms of fuel consumption is FL 350. It is estimated that about 10% of flights in Europe are not flown at their optimal cruising height because of ATC restrictions.

Figure 2.1. - Flight levels requested by airlines



Source : EUROCONTROL

2.4. Network effectiveness

Ideally, the route between two airports should be set in order to minimise the length of a flight in terms of time and distance, so that it can be flown on the most direct route using the most efficient vertical profile. In practice, however, there are various constraints:

a) route design has to take account of the need to avoid areas of potential conflict and of high traffic load; and to the need to sequence arrival traffic and segregate arrival and departure flows ;

b) national borders have the effect of fragmenting available airspace;

c) military operations restrict the use of airspace;

d) the present layout of navigationals aids, particularly the siting of radio beacons, determines routes;

e) in some cases, en-route paths will clash with airport approach paths; and

f) weather and environmental restrictions can always play a part.

Some of these factors are interdependent (for instance, radar stations are sited to cover national airspace) with the result that the individual effect of each on the network layout cannot be easily isolated. Studies have been carried out by EUROCONTROL to identify indicators which compare the lengths of the most direct paths to those of the paths actually followed. Although these analyses provide only rough measures of network effectiveness they suggest that all these factors, except weather, contribute to the problem. The studies, the results of which are summarised in table 2.3., are qualified as follows:

. they cover a varied sample of flights, using airport pairs, over a specific period. It is difficult, therefore, to extrapolate the results to other times of the year, or to flights in Europe generally;

. they assume that all flights followed the routes most normally flown (according to the EUROCONTROL Database). Actually, the distance actually flown could have varied, if Air Traffic Control had altered the routeing away from these "normal" paths.

The comparison was carried out by:

. selecting for examination a sample of routes and corresponding flights to examine;

. evaluating the distance flown according to the most commonly used itinerary, as stored in the Database of EUROCONTROL (DBE itinerary);

. evaluating the distance flown according to the theoretically most direct itinerary between terminal areas, which represents the shortest possible routing taking into account runway orientation (reference itinerary).

Because average flight distance of the sample became shorter towards the end of the 1980s, the influence of route design in terminal areas, as opposed to en-route design, became proportionally more important.

Table 2.3. - Estimation of inefficient routing

Period (m/y)	*Sample (n. of flights)*	*Average flight distance (Nms)*		*Difference (%)*
		DBE	*Reference*	
7/88	262,355	553	507	9.1
7/89	330,040	522	476	9.7
7/90	441,620	474	430	10.2
9/91	470,876	453	410	10.4
9/92	n.a.	n.a.	n.a.	n.a.
9/93	496,269	506	460	10.0
9/94	504,223	492	447	10.1

source: EUROCONTROL/Division O1

This suggests that the effect of constraints is to increase flight distances by about 10%, or around 45 Nms on average. Of this 10%, about 70% take place en route; 20% on approach to airports and 8% on departure from airport areas. According to ECAC's INSTAR study the reasons are:

- problems arising where en-route routes clash with airport areas (24%);
- routes having to be designed to avoid dense traffic areas (33%);
- the need to circumnavigate military airspace (30%);
- other factors (13%).

2.5. Technological resources

The airspace structure and network is greatly influenced by the equipment used to support Air Traffic Control services. According to its function, equipment will fall into one of three separate "domains":

- "*Communications*" includes all technology for transferring information needed for navigation, surveillance and ATM. "Ground-air" is distinct from "ground-ground", but each have separate networks for both speech and data transmission;

- *"Navigation"* refers to all equipment that facilitates en-route navigation by aircraft along the routes they have to fly;

- *"Surveillance"* means all technologies that enable ground-based ATC controllers to keep track of aircraft. The use of radar is now enhanced by the introduction of Radar Data Processing Systems (RDPS).

Communication

Three means of comunication are now in use at ATC Centres:

- air/ground voice communications (radio-telephone),

- ground/ground voice communications (telephone),

- ground/ground data communications.

Air/ground voice communications between controller and pilot are currently carried out by radio transmission, in HF, VHF and UHF.

High Frequency radio transmission is the only non-satellite communication system which allows direct communication between aircraft and ground beyond the line-of-sight. This long range communication works through the reflection of the skywave from the ionosphere and is currently used within Europe for longhaul trans-oceanic flights. Its performance is generally unsatisfactory for reliable communications because it is affected by ionospheric conditions. HF is considered to be a redundant technology about to be replaced by satellite communication systems.

VHF is the normal means of air-to-ground communications for ATC purposes for civil aircraft. But because VHF is limited to line-of-sight, ground stations must be sited so as to ensure that an aircraft will always be in line-of-sight of one of them and within a maximum distance depending upon the height of the aircraft. Aircraft overflying the European area must therefore communicate with different Centres, changing channels frequently. Each station is allocated a frequency and stations need a minimum physical separation from one another to avoid antenna interference. Within the EU there are about 350 VHF stations serving major airports and ATC Centres; but each Centre has developed its own radio communications system more or less independently. Although care is taken to ensure sufficient overlap in coverage and to prevent interference, technical approaches and solutions may be very different.

VHF is also used occasionally for air-to-air communications, most countries allocating for this purpose. VHF also allows aircrew to monitor all the traffic on a particular frequency, which enables them to hear controllers' instructions to other aircraft and thereby gain a reasonably full picture of the air traffic in the neighbourhood.

The frequency bank currently allocated to VHF aeronautical mobile communications is 118 to 137 MHz with a spacing of 25 kHz. There is an urgent need for additional frequencies over and above the 760 currently available, particularly in Central Europe. The shortfall is caused in part by poor procedures for operation and co-ordination. To alleviate the problem it may be necessary to challenge some of the present allocations of the VHF band and, if necessary, to reassign them. This would improve efficiency but by itself would not solve the problem of congestion. By 1998-2000, however, it may be possible to increase the number of channels by reducing the channel spacing to 8.33 kHz.

Another issue arises in times of heavy traffic. The limiting factor on the number of aircraft a controller can handle is the communications workload demanded by the operational, organisational and procedural requirements for handling the aircraft. This is due not to the technical performance of the communications system, nor to the lack of channels, nor even to aircraft separation standards. A reduction of the workload of the controller will be only achieved by introducing some degree of automation in aircraft handling. This will come about with the implementation of a datalink system between the aircraft and the ATC system - between the crew and the controller. In the longer term, Mode-S represents one of implementing a datalink system, which would also reduce the demands on the VHF spectrum.

UHF communications are similar to the use of the VHF communication band. Their only use for ATC in Europe is for military aircraft.

Ground/ground Voice communications are concerned, in particular, with communications between Centres. These communications provide a common network for exchanging information using direct speech links. In Europe, however, there is no standard network, and a large variety of technically different communication links and procedures are already in place at different European ACCs. The need for this network will, however, diminish after the introduction of an automated data link network developed to international standards, even if voice communications continue to play their part for resolving particular problems.

ATC voice communications are generally based on private fixed dedicated circuits connecting every pair of control centres which need to cooperate. The implementation of a Voice Communication Network suitable for ATC purposes requires the provision of extensively networked circuits, compatible equipment and standard communication procedures. For the time being, however, the basic providers of circuits are the national public telephone organisations, and the use of extensive link-ups across the network is not a standard feature of public telephone systems today.

A common approach for the implementation of such a network has been developed as part of the EATCHIP programme. This system will still be based on international point-to-point circuits but all lines, together with the switching system, will be operated as a network.

Ground/ground Data Communications enable information to be exchanged between centres, so reducing the volume of routine coordination. This information is to do with signals, flight plans, aeronautical and meteorological reports etc. Sharing it between different centres requires having proper data exchange links and appropriate communications procedures.

At present, the conventional Aeronautical Fixed Telecommunications Network (AFTN) remains the primary source for the acquisition of basic data. This network, designed some forty years ago, connects AFTN centres in all European countries. Most countries have a centralised system with one communications centre as a hub, which alone communicates with other countries' networks. Conventional AFTN links comprise teletype systems and manually operated radiotelegraphy channels. Although well proven, such links suffer from slow transmission and inadequate data protection. Moreover, the particularly poor performance of certain AFTN switching centres means that comprehensive new routeing arrangements cannot be set up. As a result, some AFTN switches and circuits are heavily overloaded, producing message loss and unacceptable transmission delays. For this reason a new, improved data interchange architecture was defined by ICAO in the mid 1970s - the Common ICAO Data Interchange Network (CIDIN). The original specification was subsequently modified to take account of the publication of the X25 communication protocol. Introducing a CIDIN network would be accompanied by replacing or upgrading old AFTN switches with the new CIDIN nodes and increasing the transmission speeds of AFTN circuits. So far, the introduction of CIDIN procedures on the ICAO plan has already taken place in some European countries (Austria, Denmark, Germany, Greece and Spain) and is in hand in others. This should increase the overall data signalling rate and switching capacity of the AFTN in the European area.

There are other ground-to-ground data communication networks for the exchange of aeronautical data and of radar data. These networks are used within regions or, at most, country-wide.

One development in communication infrastructure which will greatly improve the automatic exchange of flight plans and system coordination data between ACCs is the On-Line Data Interchange (OLDI). The verbal exchanges needed for traffic hand-overs to adjacent centres represent a significant workload for controllers. The automation of this process through the use of OLDI links has already produced significant improvements. At present, OLDI links have been established on a bilateral basis between centres in Ireland, the United Kingdom, Spain, France, Benelux, Germany, Austria and Switzerland. These are based on logic links, from a source Air Traffic Control computer system to a receiver ATC computer. There is no direct relationship between the number of such links and the number of physical circuits because relay facilities are provided at some ATC Centres; and because in some cases the OLDI application shares the same physical circuits with other facilities. The full benefit of this programme will be reached, however, only when all transmission systems have been fully harmonised.

Navigation

At present, navigation is carried out by means of VOR/DME (VHF Omnidirectional Radio Range/Distance Measuring Equipment) or NDB (Non-Directional Radio Beacon) facilities. These navaids are radio beacons, operating in VHF or MF and emitting a constant signal. The signal, received by equipment on the aircraft, guides it in the right direction. The use of these navaids has also contributed to perpetuating the existing fixed-route structure, because routes are aligned according to fixed nodes, being the points where airway beacons are located on the ground (fixes). Each individual radio station provides route coverage more than halfway to the next fix, so that coverage always overlaps. Waypoints along a route may be radial intersections from other fixes; or DME fixes from stations co-located with the present fix, or the next fix along the route. The current distribution of navaids in the European area is shown on a country-by-country basis in table 2.4.

Table 2.4. - Number of navaid types by country

Country	*VOR*	*VOR/DME*	*DME*	*NDB*
Austria	-	11	-	11
Belgium	1	9	-	8
Denmark	6	6	1	4
Finland	7	6	-	13
France	38	41	1	2
Germany	22	39	11	44
Greece	4	26	1	14
Ireland	-	4	-	6
Italy	4	43	-	28
Luxembourg	1	1	-	-
Netherlands	-	9	-	9
Norway	8	15	-	17
Portugal	-	10	-	6
Spain	9	27	-	28
Sweden	22	14	1	9
United Kingdom	5	42	-	26
Switzerland	7	5	-	6
TOTALS	134	308	15	231

Source: ANP EUR

The present VOR/DME navigation regime is generally considered satisfactory from the point of view of performance and reliability. However, they inhibit the further development of network design. The trend has been to move away from such station-oriented systems towards the much wider coverage achieved by satellite navigation systems: moving completely to such a system would, of course, remove one of the major obstacles to redesigning the European route network.

Modern navigation airborne computers enable an aircraft to determine its position by measuring its distance from two DME ground stations. This two-dimensional navigation is accurate to about 0.25 miles and makes it possible to use RNAV with current technology. However, legislation allowing RNAV use over continental airspace as a sole means has not yet been put in place, standards and regulations have still to be developed and, with RNAV so far used only on a limited basis, controllers are not yet sufficiently familiar with it.

Surveillance

The use of radar to cover European airspace has enabled controllers to handle an ever increasing level of air traffic. Before radars came into general use - and as indeed still happens today in areas where radar coverage is deficient or non-existent - flights were monitored by ATC on the basis of pilots' radio reports. The introduction of radar surveillance has given ATC controllers much better information on the progress of flights, and hence improved their ability to predict flight paths and detect possible conflicts.

Two types of radar are used in Europe: primary radar (PSR); and secondary radar (SSR), the most recent form of which is the monopulse secondary radar (MSSR).

Primary radar was first developed to monitor military flights. It provides positions (in terms of range and bearing) of any target within range by means of passive returns obtained by the reflection of radio waves directed onto the target. It therefore needs no equipment on the aircraft itself, and is a ground-based system consisting of two basic elements: a rotating antenna and a transmitter. Its range is from 60 nm (short range category) up to 200 nm (long range category); the pulse repetition frequency is from 340 Hz to 1000 Hz; and its accuracy in reporting the range and bearing (azimuth) of an aircraft is measured by the following standard deviations: 0.03 nm for the range and 0.05° for the azimuth. The quality of surveillance of PSR may be affected by fixed echoes and "clutter".

"Mode A/C" secondary radar, by contrast, is a system that makes it possible to interrogate an aircraft within range and obtain a coded reply containing, as well as range and bearing, the identity of the aircraft ("Mode A") and its altitude ("Mode C"). In this case the radar system comprises both ground-based and airborne equipment. The core elements of the ground-based radar station are the rotating antenna, a transmitter/receiver and an extractor. The extractor processes all the responses from an aircraft during each scan of the antenna and delivers a digital message containing the aircraft's position, identity code and altitude. Conventional secondary radar (SSR) and monopulse radar (MSSR) are distinguished by different techniques used for acquiring this information.

The airborne element is the transponder, connected to the aircraft antenna. Secondary radars have a range of up to 200 nm, and operate on a pulse repetition ranging frequency is from 300 to 400 Hz for conventional radars and of 200 Hz for monopulse radar. Accuracy is measured by the following standard deviations for classical SSR radars: 0.15 nm for range and 0.2° for bearing. Monopulse radars have the same accuracy as primary radars. The quality of surveillance of "classical" SSR is limited by problems of interference due to transponder saturation, while monopulse radars have brought considerable improvements in eliminating garble, reducing interferences and improving accuracy. Secondary radar is the core element of current ATC systems in Europe, and the general trend now is to install monopulse systems whose performance allows radar separations of 5 nm and less. The performance ~~of~~ secondary radars is restricted, however, by limited procedures; techniques for aircraft identification that do not allow an individual code to be used; and line-of-sight constraints.

Table 2.5. provides a summary of types and numbers of radars, on a country-by-country basis. The term "P+S" is used when the ATC is operating both a primary radar (PSR) and a secondary radar (SSR).

Table 2.5. - Number of radar types by country and age

Country	*Radar*	*Number of radar station per age (years)*				
		Total	*< 5*	*6 - 10*	*11- 20*	*>20*
Austria	P+S	6	-	2	1	3
	PSR	1	-	-	-	1
Belgium	P+S	2	-	1	1	-
	PSR	2	-	-	1	1
	SSR	1	-	-	-	1
	MSSR	1	1	-	-	-
Denmark	P+S	6	2	2	1	1
	PSR	5	-	-	1	4
	SSR	1	-	-	-	1
	MSSR	1	-	1	-	-
Finland	PSR	2	-	1	1	-
	SSR	7	-	4	3	-
	MSSR	3	3	-	-	-
France	P+S	10	-	1	4	5
	MSSR	1	1	-	-	-

Country	Radar	Number of radar station per age (years)				
		Total	< 5	6 - 10	11- 20	>20
Germany	P+S	21	6	2	13	-
	PSR	1	1	-	-	-
	SSR	1	-	-	-	1
Greece	PSR	1	-	-	-	1
	SSR	1	-	-	-	1
	MSSR	1	1	-	-	-
Ireland	P+S	1	-	-	1	-
	PSR	2	1	-	-	1
	MSSR	2	2	-	-	-
Italy	P+S	9	6	2	-	1
	PSR	9	2	1	1	5
	SSR	9	2	1	1	5
Netherlands	P+S	2	-	-	-	2
	SSR	1	1	-	-	-
Norway	PSR	5	-	1	2	2
	SSR	6	-	1	2	3
Portugal	P+S	1	-	1	-	-
	PSR	1	-	-	-	1
	SSR	2	-	2	-	-
Spain	PSR	10	1	1	2	6
	SSR	14	1	6	1	6
	MSSR	3	3	-	-	-
Sweden	P+S	8	-	1	6	1
	PSR	5	-	-	-	5
	SSR	1	-	1	-	-
	MSSR	2	2	-	-	-
United Kingdom	P+S	10	-	8	2	-
	PSR	3	-	1	-	2
	SSR	6	-	-	1	5
	MSSR	3	1	1	-	1

Source: EUROCONTROL

Radar stations are connected by dedicated telephone to Radar Data Processing Systems (RDPSs) in Air Traffic Control Centres. RDPSs convert radar data to appear on controllers' screens, tracking each aircraft's current, previous and predicted position, altitude, course and speed. A mono-radar tracker processes plots from a single radar, whereas a more accurate and reliable multi-radar tracker simultaneously processes plots from several stations. RDPSs can warn controllers of potential hazards when an aircraft's altitude or proximity to other aircraft seem likely to breach separation minima. Hazard detection extrapolates the aircraft's trajectory based on track information, but at present this is limited to Short Term Conflict Avoidance systems (STCAs).

Research is taking place into possible improvements of radar data exchange using computer networking. With such a network, each ATC centre would no longer ~~be~~ restricted to processing information from a limited number of radar stations since it would then be possible to exchange track information between centres. This would answer the need for identical radar information and identical radar separations, and eliminate problems at border areas.

There are three main functional deficiencies in Europe's radar network:

- Radar coverage. The introduction of duplicated SSR coverage - an objective of the EATCHIP programme - in the South-East of Europe is proceeding far too slowly. On the other hand, in the central area of Europe there are more radars operating than are strictly needed (see table 2.6.), as they have been sited principally to serve national requirements. Two possible results are technical problems due to the high number of radar transmissions in the area; and unnecessary increases in the costs of providing ATC services.

- The disparity of radar separation requirements. Different crteria for radar information and aircraft separation result in the need for "stopgap" measures when aircraft are handed on from one centre to another. It also means that the capacity of a route is dictated by the centre along the route which applies the greatest separation standards.

- The different technical characteristics of systems. These can put severe difficulties in the way of achieving interoperability. But even when systems are compatible, international sharing of information does not take place as much as it should - hence the over-provision of radar coverage in the core area.

Table 2.6. - Evolution of radar coverage in ECAC area

	1990	*1991*	*1992*	*1993*
Radar Coverage (entire ECAC area)				
No coverage	66.81%	66.04%	63.14%	60.29%
Single coverage	10.11%	9.50%	11.16%	11.59%
Multiple coverage	23.71%	24.47%	25.70%	28.12%
Radar Coverage (continental ECAC area)				
No coverage	36.70%	36.32%	30.68%	25.55%
Single coverage	17.89%	16.72%	19.97%	21.01%
Multiple coverage	45.41%	46.95%	49.35%	53.44%

source: EUROCONTROL

2.6. Human resources

This section looks at staff engaged in Air Traffic Services, and controllers in particular, on a country-by-country basis in terms of their numbers and different conditions of work.

At the request of the Commission, the International Federation of Air Traffic Controllers Associations (IFACTA) has carried out a survey of trends in manpower numbers, by different functions. Although there are many gaps in the data, the information gathered points to the following conclusions:

- over the last seven years some countries (for example, Belgium, the Netherlands, Sweden and the UK) have seen an increase in the number of controllers. The average yearly rate of this increase ranges from 4 to 7 percent;

- for other countries (for example, Denmark, Ireland and Italy) the number of controllers has remained stable over the period (and in one case - Finland - it has slightly decreased).

An assessment of manpower requirements was made in 1993, as part of the EATCHIP programme, which concluded that there was a shortage of air traffic controllers which would last until at least 1997; and that this would have an impact on traffic capacity. Another conclusion was that in some countries the deployment of controllers was less than fully effective, due largely to low motivation of staff and poor management practices.

The figures in the table appear to confirm the shortage of trained staff in certain areas. This shortage may be due in part to disparities in selecting and training staff, which requires considerable resources of time and money. Efforts are under way to harmonise aspects of human resources in this field by establishing common procedures for selection, training and licensing.

Differences in social and cultural attitudes are reflected in different working conditions, as shown in table 2.8. There are marked differences in standard working times, which could explain disparities both in productivity and in salaries.

Table 2.7. - Number of air traffic controllers available

Country	Function	1989	1990	1991	1992	1993	1994	1995
Belgium	Tower/Approach		109	115	126	135	144	138
	En-route		80	81	89	86	87	94
	TOTAL	152	189	196	215	221	231	232
Denmark	Tower/Approach					106	108	105
	En-route					92	96	95
	TOTAL					198	204	200
Maastricht	Tower/Approach							
	En-route	152	145	155				171
	TOTAL	152	145	155				171
Finland	Tower/Approach					168	164	170
	En-route					69	70	60
	TOTAL	213	220	227	236	237	234	230
Germany	Tower/Approach							
	En-route							
	TOTAL	1180	1225	1334				
Ireland	Tower/Approach			60	60	65	65	65
	En-route			105	105	110	110	110
	TOTAL		166	165	165	175	175	175
Italy	Tower/Approach					501	515	
	En-route					668	685	
	TOTAL					1169	1200	1200
Netherlands	Tower/Approach	67	69	71	77	80	78	77
	En-route	58	67	71	70	71	77	76
	TOTAL	125	136	142	147	151	155	153
Spain	Tower/Approach			370				
	En-route			452				
	TOTAL	800	727	822				
Sweden	Tower/Approach			330	325	340	345	345
	En-route			245	230	245	260	280
	TOTAL			575	555	585	605	625
United Kingdom	Tower/Approach			650				
	En-route			1150				
	TOTAL	1500	1600	1800		1900	1900	2000

source: IFATCA

Table 2.8. - Work and rest scheme in Europe

	working days per			working hours per week	breaks incl.	maximum length of a shift (hrs) day / night	max continuous working time without a break / day-shift (hrs)		total duration of breaks (hours)		minimum time-off between 2 shifts (hrs)	max number of consecutive days of work without a day-off	official allowed hours of sleep during night
	week	month	year				radar	non-radar	day	night			
AUSTRIA													
BELGIUM	5	20	220	35	yes	9 / 10	3.30	3.30	.30	-	9	12	no
CHANNEL ISLANDS													
DENMARK	5	20	210	36	yes	7.20/10,20	1.30	1.30	2	3	8	10	no
EUROCONTROL	5	20	200	38.5	yes	8.45/10.30	4	4	1.30	min 4	10	4	yes
FINLAND	5	22	228	35	yes	7.30/12.30	1 - 3	1 - 7.5	1	2	9	6	no
FRANCE	3.5	14	140	32	yes	11/12	2.5	5	?	?	12	3	yes
GERMANY	4 - 5	20 - 22	205	38.5	yes	10 / 10	4	6	2.30	2.00	10	6	yes
GREECE													
IRELAND	6	-	-	41	yes	8 / 11	2	3	1	1.45	9	6	no
ITALY	5	20	243	35	yes	7 /11	2	2	1.30	4	7	3 - 4	no
LUXEMBOURG													
THE NETHERLANDS	5	22	234	40	yes	8 / 8	2.20	5.20	1.20	3	10	10	yes
PORTUGAL													
SPAIN	3.5	14	140	32	yes	8 / 10	2.30	8	2.10	5	6	3	yes
SWEDEN	5	21	200	38	no	14 / 14	2	4	1	-	8	10	no
U K	4.5	19	230	35	yes	10 / 10	2	4	2	2	12	6	no

2.7. The costs of services provided

The economic appraisal of the cost of facilities and staff engaged for the provision of ATS is based on the yearly expenditure of national administrations, which is reported to EUROCONTROL annually by the countries participating in the Central Route Charges Office (CRCO). Member states of CRCO operate a common charging system, in which the costs for actual services provided, added to EUROCONTROL's central costs, are used to establish a cost-base from which the national unit rates of charge can be calculated.

The cost-base is worked out in accordance with generally accepted accounting principles for investment expenditure and operating costs. Investment expenditure, on equipment and buildings, is taken into account by amortising its cost on the basis of its expected operating life. The two components of this cost are depreciation (the amount of capital actually in service); and interest (which is related to the net value, in terms of cost - depreciation, of the capital invested). Operating costs are those for Air Traffic Services, communications, meteorological services and Aeronautical Information Services, each classified in terms of maintenance, operations, training, research and administration.

The capital and operating costs for EUROCONTROL Headquarters - including the Central Flow Management Unit, the Experimental Centre and the Institute of Air Navigation Services - are added to Member States' own national costs pro rata with Member States' contributions to the EUROCONTROL budget. EUROCONTROL's capital and operating costs for the Maastricht Centre are added to national costs pro rata with the use of the airspace of the participating countries for which route services are provided. Table 2.9., and figure 2.2., illustrate the changes in en-route services costs in both actual and deflated terms (at 1986 prices).

The overall cost of Air Traffic Services in 1993 amounted to 2.147 billion ecus..

In order to express the series of costs at constant prices (1986), the consumer price index EUR12* has been used. Data given, on the deflated cost of air traffic services in EURO/88, show a slight increase till 1989 (3.4 percent on average) and a sustained increase from 1989 onwards (10 percent on average). In the period under analysis (1986-1993), the contribution of EUROCONTROL cost to overall cost has increased from 7 percent to 11 percent.

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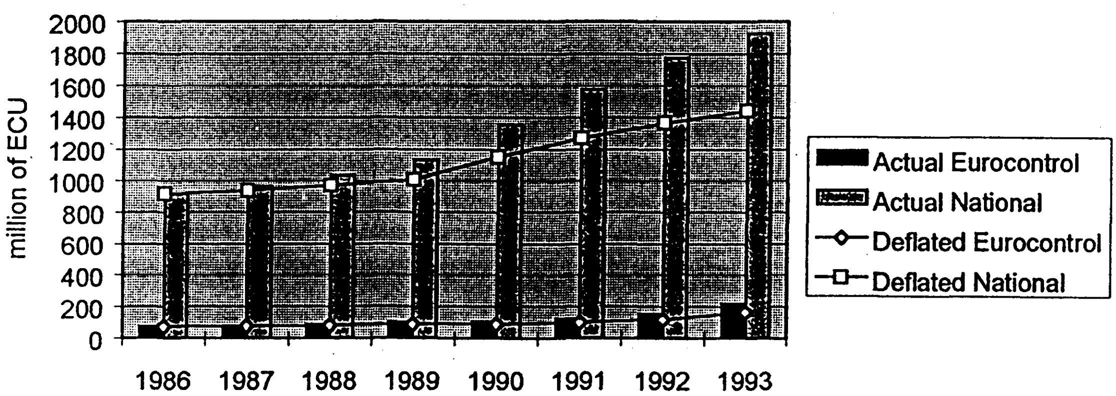
* The EUR12 index is a weighted average of the national price indeces of the Members of the European Union.

Table 2.9. - En-route ATS cost in EURO/88* (million of ECU)

	1986	1987	1988	1989	1990	1991	1992	1993
Actual costs								
National	916	963 +5 %	1034 +8 %	1130 +10 %	1357 +19 %	1574 +16 %	1772 +13 %	1927 +11%
EUROCONTROL	73	79 +8 %	87 +10 %	101 +16 %	105 +4 %	126 +21 %	154 +22 %	220 +42%
Total	989	1043 +5 %	1121 +7 %	1231 +9%	1462 +20 %	1701 +16 %	1927 +13 %	2147 +9 %
Costs in 1986								
National		936 +2 %	969 +4 %	1005 +4 %	1148 +13 %	1269 +11 %	1365 +8 %	1442 +8 %
EUROCONTROL		77 +5 %	81 +6 %	90 +10 %	88 -1 %	102 +15 %	119 +17 %	164 +38%
Total		1013 +2 %	1050 +3 %	1094 +4 %	1236 +14 %	1371 +11 %	1484 +8 %	1606 +6 %

source: CRCO

Figure 2.2. - En-route ATS cost in EURO/88



* EURO/88 is formed by Belgium, Luxembourg, Germany, France, United Kingdom, Netherlands, Ireland, Switzerland, Austria, Spain and Portugal.

Member States' costs are divided into:

- Staff costs,
- Other operating costs (maintenance, consumables, power etc),
- Depreciation,
- Interest.

Costs between 1991 and 1994, using this breakdown, are shown in table 2.10. - based on 11 European countries (the "EURO/88" group, with Switzerland excepted and Greece included).

Overall, the main component is staff costs, which account for over half. But the relative importance of each cost component to the total national cost differs from country to country. This is explained by the following:

- staff costs account, on average, for 56% of total costs, but with a standard deviation of 9%;
- other operating costs account for 21% on average, with a standard deviation of 12%;
- depreciation accounts for 13%, with a standard deviation of 5%;
- interest accounts for 10%, with a standard deviation of 6%; and
- other costs count for 0%, but with a standard deviation of 2%.

Table 2.10. - Changes in national ATC costs 1991-1994 (11 countries)

Costs	1991		1992		1993		1994	
Actual costs (million ECU)								
Staff	765	49 %	864 +13 %	49 %	999 +16 %	52 %	1118 +12 %	52 %
Operating costs	423	27 %	485 +15 %	28 %	471 -3 %	25 %	499 +6 %	23 %
Depreciation	183	12 %	213 +17 %	12 %	255 +20 %	13 %	308 +20 %	14 %
Interest	153	10 %	159 +4 %	9 %	161 +1 %	8 %	187 +16 %	9 %
Other	34	2 %	32 - 4 %	2 %	32 -2%	2 %	35 +12 %	2 %
TOTAL	1557		1754 +13 %		1918 +9 %		2147 +12 %	
Costs in 1991 (million of ECU)								
Staff			830 +8 %		929 +12 %		1012 +9 %	
Operating costs			465 +10 %		434 -7 %		453 +4 %	
Depreciation			205 +12 %		237 +16 %		279 +18 %	
Interest			151 -1 %		146 -3 %		165 +13 %	
Other			32 -7 %		30 -4 %		33 +10 %	
TOTAL			1679 +8 %		1767 +5 %		1937 +10 %	

source: CRCO

3. THE DEMAND FOR EUROPEAN AIR TRAFFIC SERVICES

3.1 The developing roles of ATS users

There are three main users of Air Traffic Services:

- Commercial Air Transport,
- Military Aviation,
- General Aviation.

Commercial Air Transport includes all scheduled and charter airlines. General Aviation includes:

- commercial (Air Taxis, private charters, corporate aircraft etc); and
- leisure (private light aircraft, gliders, balloons etc).

The relative roles of these categories in 1994, when 4.7 million flights took place in the "EURO/88 area", is shown by the fact that 97 percent of flights were civil operations (of which 92% were commercial) while military flights accounted for only 3 percent.

The main source of data on the en-route operational workload of air traffic control is EUROCONTROL's Central Route Charges Office (CRCO). From an analysis of en-route communications one can ascertain the number of flights operating under instrument flying rules (IFR) handled at en-route control centres (flights operating under visual rules - VFR - are excluded). The data enables a comprehensive analysis to be made of the demand for airspace use. For consistency, data coverage is limited to the eleven countries who participated in the Route Charges System before 1988 (since then, a further six countries have joined the System; and the former East Germany has been incorporated into the FRG)*. Global traffic figures are shown in table 3.1.. The number of IFR flights controlled in the "EURO/88" area came to 4.72 million in 1994 and represented a total of 2.923 million kilometers flown. Although the number of flights had grown more slowly in 1991 and 1993, flights became steadily longer - the average distance per flight rose from 582 km in 1988 to 618 km in 1994.

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* EURO/88 is formed by Belgium, Luxemburg, Germany, France, United kingdom, Netherlands, Ireland, Switzerland, Austria, Spain, Portugal.

Table 3.1. - Trend of air traffic control workload in the "EURO/88 group of countries

	1988	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*
Total number of flights	3605491	3876962	4098461	4180127	4459574	4521977	4723188
Increase over previous year	-	+7.53%	+5.71%	+1.99%	+6.69%	+1.40%	+4.45%
Total kilometers flown (million)	2099	2249	2394	2490	2677	2776	2923
	-	+7.15%	+6.45%	+4.01%	+7.51%	+3.70%	+5.30%
Average kilometers per flight	582	580	584	596	600	614	619

source: CRCO

3.2. Distribution and patterns of demand

The CRCO data also show the pattern of air traffic in Europe. In table 3.2. flights are categorised as follows:

- "Domestic": flights wholly within one of the "EURO/88" countries.
- "Internal": international flights operated from one of the "EURO/88" countries to another.
- "External": international flights between the "EURO/88" group of countries and other countries.
- Overflights.

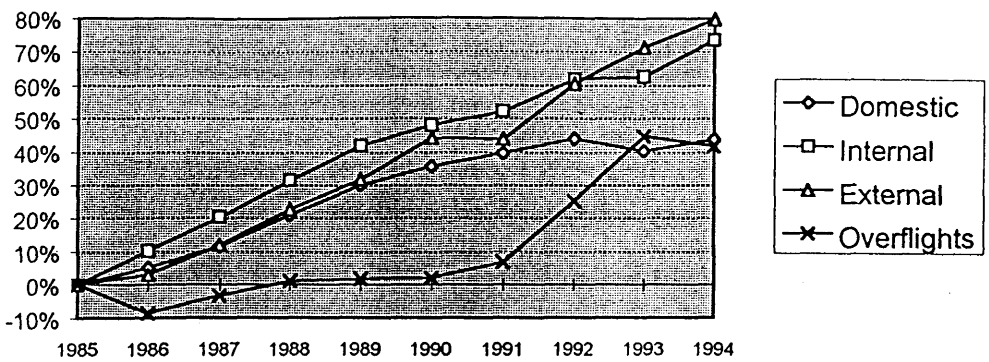
Figure 3.1. shows the growth in air traffic control activity during the past ten years, based on 1985, by category of traffic.

Table 3.2. - Number of IFR flights handled in EURO/88 in past decade

TYPE OF TRAFFIC	*1985*	*1986*	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*
Domestic	1203091	1264356	1342253	1455717	1565133	1632485	1680313	1733481	1688161	1730783
Internal (international)	814861	897937	980962	1070381	1155993	1205757	1239891	1317597	1324891	1414082
External (international)	837105	862166	936642	1026868	1102948	1207155	1204377	1343369	1433675	1504586
Overflights	51994	47496	50253	52525	52888	53064	55546	65127	75250	73737
TOTAL	2907051	3071955	3310110	3605491	3876962	4098461	4180127	4459574	4521977	4723188

source: EUROCONTROL/Division DED.4-STATFOR

Figure 3.1. - Growth of IFR flights handled in EURO/88



Despite the economic effects of two major global events (the Gulf War of 1990, and the economic recession of 1991-93), since 1985 there has been strong growth in international traffic, with yearly average increases of 6.3 percent in "internal" traffic and 6.7 percent in "external" traffic. By contrast, "domestic" traffic grew more slowly, especially in the early 1990s, with an average annual increase over the ten year period of only 4.1 percent. As a result, the share of international traffic ("internal" plus "external") increased from 56.8%in 1985 to 61.8%in 1994. (Similarly, the sharp increase in the number of overflights after 1991 was mainly due to the growth of international flights from and to European countries outside the "EURO/88" area.) For air traffic control, this has meant that international traffic has accounted for an ever increasing proportion of sector-to-sector transfer, throwing into sharper relief the shortcomings of European ATS as a grouping of disparate national systems.

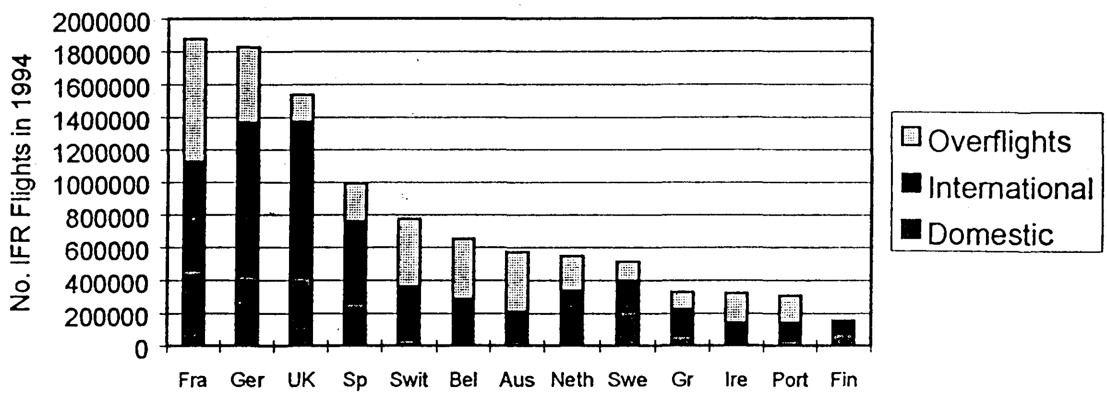
Table 3.3., and figure 3.2., look at the pattern of IFR flights in 1994. For each country, these are shown in terms of total flights; flights operated within national boundaries (domestic); international flights; and overflights. Under the symbols R_T, R_D, R_I and R_O are shown the respective ranking of each country in terms of traffic volume for each category. For domestic flights, activity is clearly correlated to the size of the country; with international flights, there is a clear concentration in the core-area (the UK, Germany and France); and most overflights take place along the north-south corridor (Belgium-Germany-France-Switzerland-Austria).

Table 3.3. - Annual number of IFR flights in 1994

Country	*Total*	R_T	*Domestic*	R_D	*International*	R_I	*Overflights*	R_O
Belgium/Luxemb.	653908	6	6233	13	278905	7	368770	4
Germany	1830726	2	424164	2	945513	2	461049	2
France	1877914	1	462206	1	664297	3	751411	1
United Kingdom	1536042	3	416842	3	954148	1	165052	9
Netherlands	550171	8	19935	11	319431	6	210805	7
Ireland	321235	11	15199	12	124364	11	181672	8
Spain	991335	4	260124	4	502463	4	228748	6
Portugal	303611	12	32317	9	106923	12	164371	10
Switzerland	774818	5	32661	8	330333	5	411824	3
Austria	570776	7	27120	10	183579	9	360077	5
Greece	326285	10	59801	7	164364	10	102120	12
Sweden	515452	9	210253	5	189141	8	116058	11
Finland	154573	13	73142	6	70890	13	10541	13

source: EUROCONTROL/Division DED.4-STATFOR

Figure 3.2. - Annual Number of IFR Flights in 1994



The monthly distribution shows how traffic decreases during the winter and increases in summer: this is more marked for international flights. From 1991, July has been the busiest month of the year.

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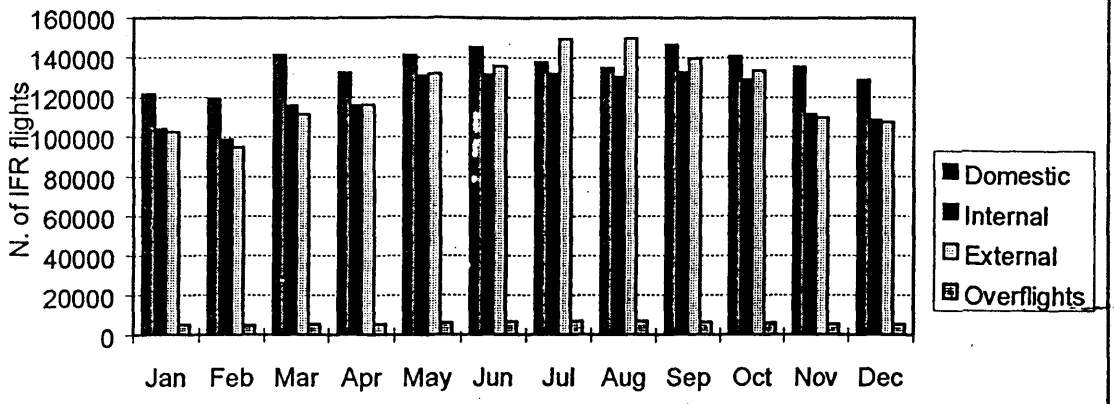
Figure 3.3. - Monthly distribution of IFR flights in 1994



4. THE LEVEL, AND QUALITY, OF ATS SERVICES

4.1. Indicators of service quality

There are three main criteria by which the success of a European ATM system can be judged:

- the level of safety achieved;
- the quality of service performed; and
- the value for money represented by the services delivered.

The system is assessed against these criteria using performance indicators:

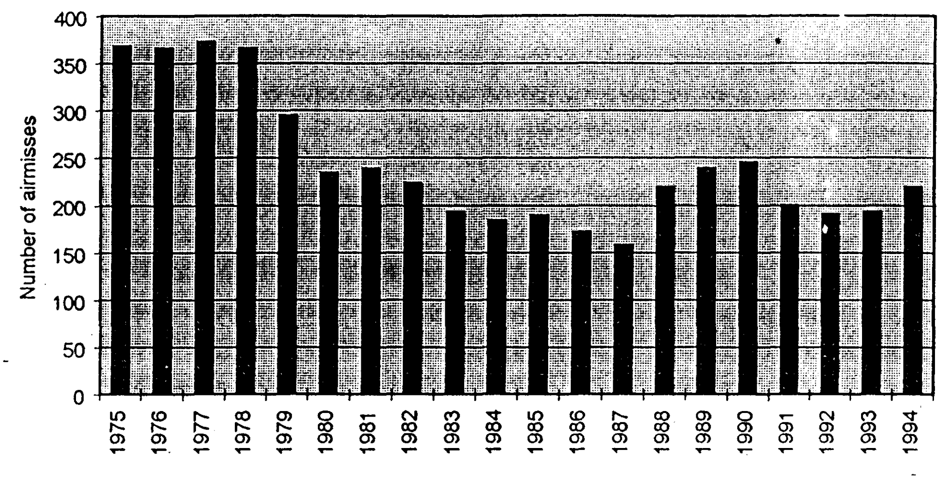
- the number of airmisses (as an indicator of safety levels);
- delay monitoring (as an indicator of service quality);
- the levels of en-route charges; and productivity factors (as indicators of value for money).

4.2. Level of safety

Over the last 15 years, the number of airmisses recorded by IATA in the European region has remained relatively stable (with the exception of 1989 and 1990 - see figure 4.1). At the same time, traffic increased tremendously, which has meant a steady reduction in the rate of airmisses as a proportion of the number of flights handled by the ATC system.

It has to be noted that this continuous improvement was achieved at the same time that the introduction of new technologies allowed a gradual reduction in separation between aircraft. Neither was it adversly affected by airspace congestion and consequent delays : on the contrary, these delays were often introduced to maintain

Figure - Total airmisses for EUR region (source IATA)



the safety level of the system at the expense of its punctuality.

However, the growth of air transport continually keeps up the pressure on an already overcrowded system and new methods of assessing safety against capacity will have to be developed if the improvement in airmisses is to be maintained.

4.3. Factors influencing airspace capacity

"Airspace capacity" means the maximum number of aircraft that can be handled simultaneously by a typical sector while maintaining an acceptable safety level. Capacity will therefore depend on:

- the minimum separation between aircraft, and hence the maximum potential number of aircraft movements at any one time; and

- the size of the sector, in terms of the volume of airspace controlled.

Capacity can be improved by increasing the number of flights handled in the sector; by decreasing their separation; and by reducing the size of the sector's airspace while maintaining the number of flights controlled.

The degree of separation between aircraft depends on several factors. The principal one is the criteria applied for radar separation, which will depend on the accuracy of the radar system and the display representation. Standards for all radar sub-systems are set by criteria for the performance of the radar sensor, and the central data processing equipment. Other factors may affect the use of a particular radar system, and hence the separation minima:

- Communications. It is essential to have proper means of communication, with proper coverage and performance, which always allow immediate contact with aircraft.

- Meteorology. Adverse weather conditions can mean that wider separation distances has to be allowed between aircraft.

- Airspace Management and Procedures. This means having a type of airspace structure and network which has the maxinum flexibility to adapt to different radar separation requirements.

- The human element. This includes pilots, who must be able to monitor and respond promptly to controllers' instructions, as well as the controlllers themselves. The extent of controllers' expertise, experience and stamina are critical factors when establishing the maximum workload they can cope with.

To an extent it is possible to increase capacity and solve the problems linked to workload by decreasing the size of the sector - the area of responsibility of the individual controller. Increasing the number of sectors in this way could, however, give rise to new problems by increasing the amount of coordination needed.

The benefits of closer radar separation within a particular sector can be lost if separation distances have to be increased significantly as aircraft approach the sector boundaries to be transferred to the next en-route sector. Indeed, the disparity in radar separation standards on international routes is one of the single most inhibiting factor in determining capacity in Europe. Before a single minimum radar separation standard could be applied across the European area, however, controllers would need to be able to have a clear picture of the traffic in neighbouring sectors as well as their own. This would require overlapping radar and R/T coverage; standard display screen characteristics, when two adjacent aircraft are under control of different centres; compatible airspace structures on both sides of the sector boundary; and an understanding of the procedures and equipment in neighbouring sectors.

The main failing of the present system, in terms of meeting demand, is lack of capacity. This stems principally from the relatively low degree of interoperability of equipment and the inefficient deployment of controllers. Scarce capacity means delays, and less flexibility in the use of airspace. Delays are often regarded as a useful indicator of system capacity : when and where they are reported, shortage of ATC capacity could be their cause. However, measuring capacity levels in this way first requires a proper analysis of the different possible causes of delay. In May 1995 ECAC's INSTAR Study Group concluded that there were three main causes of capacity bottlenecks and consequent delay. Lack of technical infrastructure, especially the quality and quantity of radar coverage, accounts for about 10 percent of total ATM delays, while staff shortages in ATC centres account for about another 10 percent. The study concluded, however, that by far the biggest cause - accounting for some 80% of delays - was the effective limit on a controller's workload, especially in the core area, in terms of the maximum number of flights that he can safely handle at any one time. This limit will vary from sector to sector, and may indeed depend in large part on the individual controller. This factor is also a result of a system not offering the controller optimal working conditions. Therefore, the many factors involved (poor airspace design, deficiencies in technical equipment, controller workload) need to be studied in depth before conclusions can be drawn about improving efficiency in this area.

4.4. Assessing the causes of ATC delays

Delays affect both aircraft operators, because increased flight times directly affect airlines' costs; and passengers, in terms of inconvenience and reduced reliability of flying compared to other means of travel. Delays also mean that airspace capacity is not used effectively, since the effect is to spread the same flow of flights over a longer period; and the resulting increase in ATC operators' costs per kilometer flown is directly reflected in user charges.

Although EUROCONTROL, IATA and AEA monotor delays across Europe, current tools for measuring delays are still being developed. Delays resulting from ATC activity cannot always be directly identified, or their causes and impact assessed properly. There are significant limitations, therefore, in our understanding of the influence of capacity capacity shortages. Indeed, system elements are so interdependent that a some quite unrelated factor - such as weather, or an accident which blocks a key feeder road to an airport - may upset flight schedules in the first place; but a fundamental shortage of ATC capacity may exacerbate the disruption. More research is needed on these interactions.

There are three main sets of statistics on delays. Two have been developed by airlines organisations (IATA and AEA) and the third consists of data from national Flow Management Units (FMU) which has been continued, more recently, by EUROCONTROL's Central Flow Management Unit (CFMU). Table 4.2. summarises the main techniques used in assembling each one. All three surveys take into account departure delays.

The IATA survey collects data regularly from a sample of carriers - international flights by 16 European and American carriers - and analyses them on a monthly basis. While the IATA survey is necessarily limited in scope, it is useful in that it:

- samples the delays incurred by major international carriers for all their international scheduled flights - a particularly important sector of the market;
- shows historic trends for different causes of delay; and whether they are related directly to ATC operations, or more indirectly through flow restrictions, industrial action etc;

Figure 4.3. - Average delay per delayed flight on a monthly basis

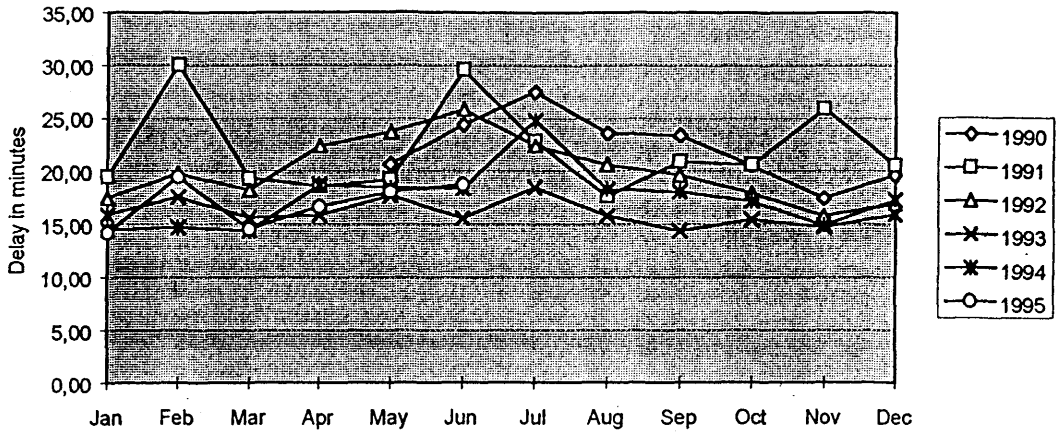


Table 4.2. - General criteria of present statistics on delays

Source	*Start year*	*Collection method*	*Calculation method*	*Type of delay*	*Sample* (no of carriers/ yearly flights)
IATA	1989	Report of airlines	Difference between actual off-blocks time and scheduled time of departure (>5 minutes)	ATC & ATC related causes	16 1.4 million
AEA	1986	Report of airlines	Difference between actual off-blocks time and scheduled time of departure (>15 minutes)	Airport & ATC caused	25 1.4 million
CFMU	1985	Report of FMUs	Difference between last requested slot time and last allocated slot time (>5 minutes)	Flow management restrictions	all carriers 4.7 million

- attempts to draw conclusions about the extent to which delays are attributable to weaknesses in the ATS structure, in terms of capacity shortages resulting from a lack of technical or human resources.

Table 4.3. shows the main results of the IATA survey over the last five years.

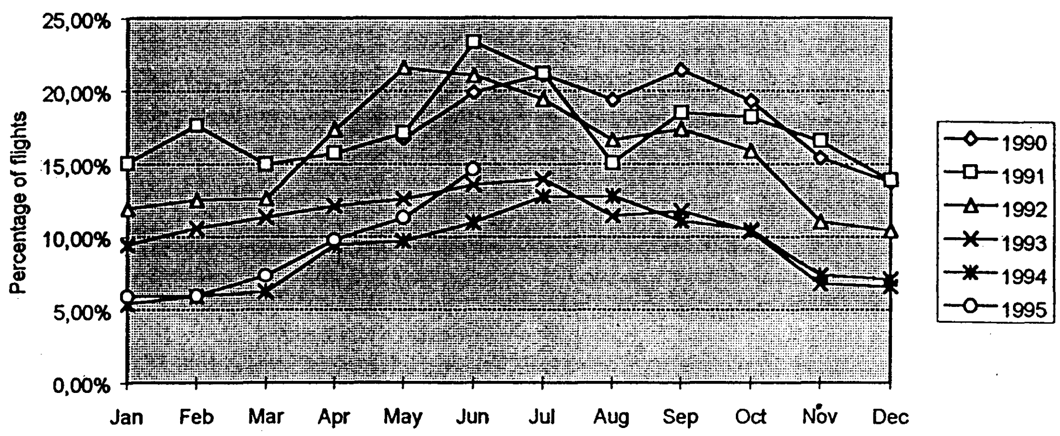
Table 4.3. - Yearly results of IATA-ATC delay survey (year: from July to June)

	90/91	91/92	92/93	93/94	94/95
Total number of flights	1,034,760 -	1,173,018 +13.4%	1,291,311 +10.1%	1,464,663 +13.4%	1,475,762 +0.8%
Number of flights delayed	185,719 -	196,751 +5.9%	173,153 -12.0%	133,502 -22.9%	144,373 +8.1%
Percentage of flights delayed	17.95%	16.77%	13.41%	9.1%	9.8%
Delay in minutes	4,231,040 -	4,276,069 +1.1%	3,109,602 -27.3%	2,191,292 -29.5%	2,612,437 +19.2%
Average delay per delayed flight	22.78	21.73	17.96	16.4	18.1

source: IATA

Although the sample has changed over the period, the figures show the trend: after

Figure 4.2. - Montly percentage of flights delayed



steady improvements up to 1993/94, the situation deteriorated last year. Figures 4.2. and 4.3. contain the same information on a monthly basis, showing how delays tend to peak over the summer.

The FMUs delay survey was started in 1985 on a small scale, and was expanded in 1991 when the CFMU took over responsability for it. The object of this exercise was to survey all flights planned to operate on restricted routes, flying from areas for which the FMUs had flow management responsibility to other European destinations. All flights were included whenever they were affected by traffic flow restrictions, even if they experienced no delay. Delays were calculated in terms of the time between the initial slot allocation and actual take-off (times of less than 10 minutes were disregarded).

The departure and destination areas in the sample were initially selected in order to concentrate on looking at the North-South flow (from the UK, France, Benelux and FRG to Italy, France, Spain and Greece). They were later extended, however, to include other areas where traffic growth threatened a need for restrictions (such as Gatwick airport, and the Netherlands); and the inconsistencies resulting from this and other changes preclude the production of exhaustive historical statistics.

Table 4.4. - Monthly results of FMUs delay survey from 1986 to 1989

YEAR	*MONTH*	*WEEK*	*Traffic flow*	*Reported flights*	*Reported delay*	*% delayed flights*	*Average delay*
1986	June	23-29	16391	2773	16745	16.92%	6.04
	July	21-27	16148	3029	13371	18.76%	4.41
	August	25-31	16323	2654	14683	16.26%	5.53
	Total		48862	8456	44799	17.31%	5.30
1987	June	22-28	17763	4267	60748	24.02%	14.24
	July	20-26	17395	2986	26788	17.17%	8.97
	August	24-30	17810	3176	19083	17.83%	6.01
	Total		52968	10429	106619	19.69%	10.22
1988	June	20-26	19445	8986	125744	46.21%	13.99
	July	18-24	18582	9579	125224	51.55%	13.07
	August	22-28	19108	9946	106336	52.05%	10.69
	Total		57135	28511	357304	49.90%	12.53
1989	June	26-02	21969	12318	237094	56.07%	19.25
	July	24-30	21147	12391	211292	58.59%	17.05
	August	28-03	21780	11065	137793	50.80%	12.45
	Total		64896	35774	586179	55.13%	16.39

source: EUROCONTROL

Nevertheless, table 4.4. has been drawn up to compare, year by year, delays in three separate weeks over June, July and August, even though the sample coverage has changed over the period.

Bearing these limitations in mind, the table shows how delays rose dramatically in 1988 from a stable level in 1986 and 1987, both in terms of the number of delayed flights and length of the average delay.

From 1992, with the inauguration of EUROCONTROL's CFMU, a coordinated approach has meant that data could be collected on a daily basis and analysed monthly. At the same time, the survey was extended to cover the entire European region, recording:

- the estimated total number of flights per month that passed through the area of an FMU's responsibility (from data supplied by CRCO);

- the number of slots requested for flights subject to flow control measures which were obliged to request slots;

- the delay between a requested slot time and the actual take-off time if this was longer than five minutes.

Table 4.5. shows the results, year by year. Last year saw about 160,000 hours of delays - the percentage of flights delayed increased to 8.9%; and the average delay went up to 23 minutes. This setback is confirmed when the information is analysed

Figure 4.4. - Monthly percentage of flighs delayed (CFMU)

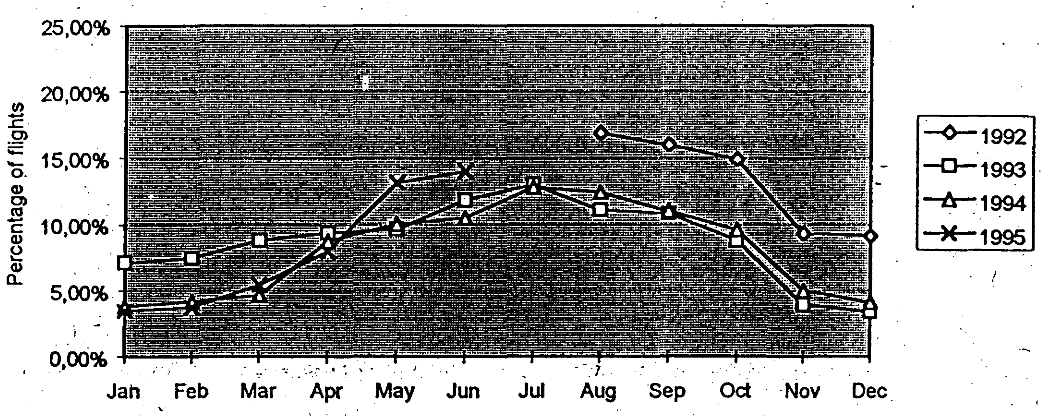
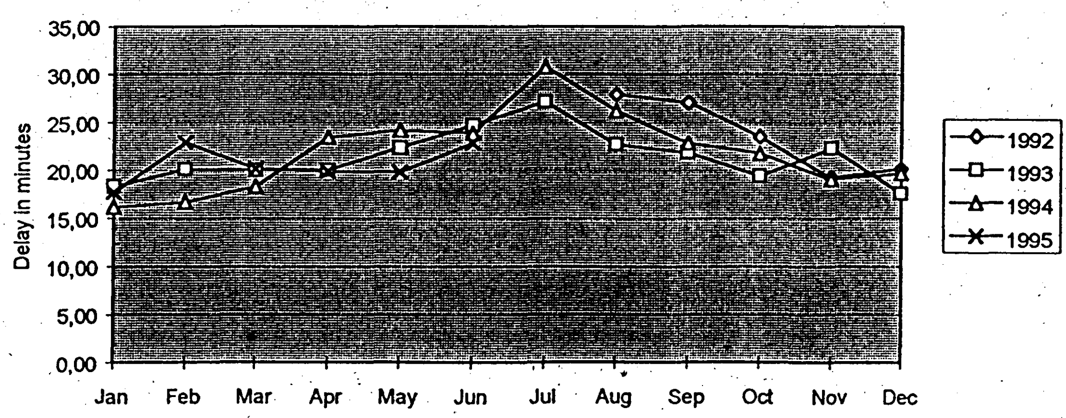


Figure 4.5. - Average delay per delayed flight (CFMU)



on a monthly basis (figures 4.4. and 4.5.).

Table 4.5. - Yearly results of CFMU delay survey (year: from July to June)

	92/93	93/94	94/95
Total number of flights	3,698,061	4,443,245	4,663,969 +5.0%
Number of flights delayed	408,994	357,652	415,108 +16.1%
Percentage of flights delayed	11.1%	8.1%	8.9%
Delay in minutes	9,464,541	8,046,979	9,558,647 +18.8%
Average delay per delayed flight	23.1	22.5	23.0

(year 1992 from August)
source: EUROCONTROL

A recent review by the CFMU looked at the 30 busiest sectors in Europe in 1994. Leaving aside delays of less than 15 minutes, it still attributed between 100,000 and 170,000 hours of departure delay to ATC causes. Three main causes are set out in table 4.6. below.

Table 4.6. - Estimation of delay and related causes in 1994

Causes	Yearly Delay			Improvement measures
	Proportion		Hours	
Airport and ATM constraints	100%		200,000	
ATM constraints	50 - 80%	100%	100,000 to 170,000	
- Inefficient rostering		10%	10,000 to 17,000	Recruit controllers Improve rostering
- Lack of technical infrastructure		8%	8,000 to 14,000	Complete radar coverage
- Maxima placed on controller workload in elementary sectors		82%	82,000 to 140,000	Revise airspace structure/network Implement joint use of airspace Improve flow management Improve controller tools

Source: Ecac Instar Study Group - May 1995

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4.5. En-route charges

Route charges are levied for the use of en-route air navigation facilities and services. Within the EU all Member States except Italy, Finland and Sweden operate a common charging system for en-route air navigation services in the airspace for which they are responsible. This common system is operated by the Central Route Charges Office (CRCO) of EUROCONTROL on behalf of the Contracting States.

The route charges recover the costs incurred by Air Traffic Control organisations for en-route air navigation services (see paragraph 2.7.). The overall charge exacted ~~by~~ a Contracting State equates to the sum of individual charges for flights which have entered the airspace of that State. The individual charge for a flight is calculated by multiplying the national unit rate of charge by the number of "service nuits" of that flight. For each country, the national unit rate of charge is fixed each year by dividing the national en-route facility cost-base by the total number of "service units" in that country's airspace in that year. The calculation of "service units" is a function of the distance flown by an aircraft, expressed in terms of one hundredths of the great circle distance between the point of entry into the country's airspace and the point of exit from it, multiplied by the weight factor of the aircraft expressed as the square root of its maximum certificated take-off weight. The points of entry into and exit from that airspace are assumed to be along the most commonly used routes between the airports of departure and arrival. "Unit rates of charge" for a year are fixed at the end of the previous year, on the basis of actual costs. There is a mechanism which allows any consequent disparities to be adjusted subsequently.

Finally, these values must refer only to chargeable flights. (Some flights are usually exempted - such as those by aircraft under 2 tons, State aircraft, search and rescue flights, military flights, training flights, and Navaid check flights.)

Table 4.7. and figure 4.6. show how the unit rate of charge has changed between 1985 and 1995 for the 11 European countries in the "EURO/88" area, in terms of:

- the average unit rates calculated by dividing the sum of the forecast costs chargeable to users by the sum of the forecast chargeable service units ; and expressed in current and constant terms (1985) ;

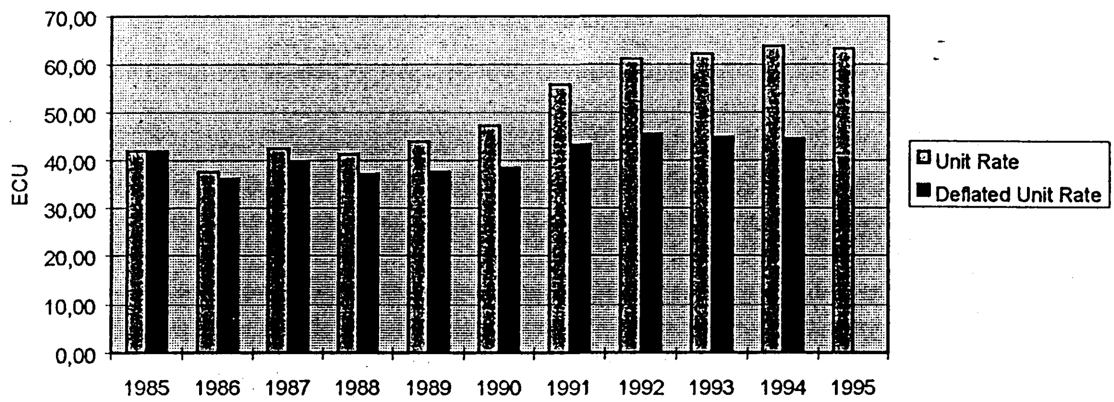
- the sum of costs, and of number, of chargeable service units forecast to determine previous unit rates.

Table 4.7. - Average unit rate in the "EURO/88" area.

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Unit Rate (ECU)	41.92	37.58	42.49	41.12	43.92	47.29	55.91	61.16	62.36	63.83	63.38
	-	-10.35%	+13.06%	-3.22%	+6.81%	+7.66%	+18.24%	+9.39%	+1.96%	+2.36%	-0.71%
Deflated Unit Rate (ECU in 1985)	41.92	36.14	39.71	37.04	37.54	38.47	43.31	45.44	44.83	44.51	-
	-	-13.80%	+9.89%	-6.71%	+1.33%	+2.50%	+12.56%	+4.92%	-1.34%	-0.71%	-
Costs forecasted (million of ECU)	785.63	738.83	892.08	964.50	1139.04	1288.05	1685.24	1911.10	2166.10	2247.52	2406.79
	-	-5.96%	+20.74%	+8.12%	+18.10%	+13.08%	+30.84%	+13.40%	+13.34%	+3.76%	+7.09%
Chargeable Service Units forecasted (millions)	18.74	19.66	20.99	23.46	25.93	27.24	30.14	31.25	34.74	35.21	37.97
	-	+4.9%	+6.8%	+11,7%	+10.6%	+5.0%	+10.6%	+3.7%	+11.2%	+1.4%	+7.8%

Source: CRCO

Figure 4.6. - Evolution of average unit rate in EURO/88



Real unit rates wavered up and down between 1985 and 1990, and then rose sharply (the average growth in 1991 and 1992 was 8.7%). Since 1992 real unit rates have been slowly falling. Looking at the influence of the different factors that determine unit rates (the cost-base and forecast service units), the trend is explained as follows:

- until 1990 the increased value of service units (yearly average, 7.5%) was accompanied by a - lower - increase in the cost-base (yearly average, 5.9%);

- after 1990 there was a stronger increase in the cost-base (yearly average, 10.6%) which was not matched in 1991 and 1992 by a corresponding increase in the value of service units;

- most recently (since 1993), this trend has reversed due to a sustained increase in traffic.

Further considerations can be drawn when the basis of the values of costs, service units and unit rates are expressed in actual terms.

Table 4.8. shows:

- the number of actual total service units in the "EURO/88" area;
- the number of chargeable service units in the area;
- the number of service units exempted;
- the actual unit rate (derived by dividing actual costs by actual service units, representing the theorical charge that would have been imposed on airspace users each year).

Table 4.8. - Actual Service Units generated in EURO/88 area

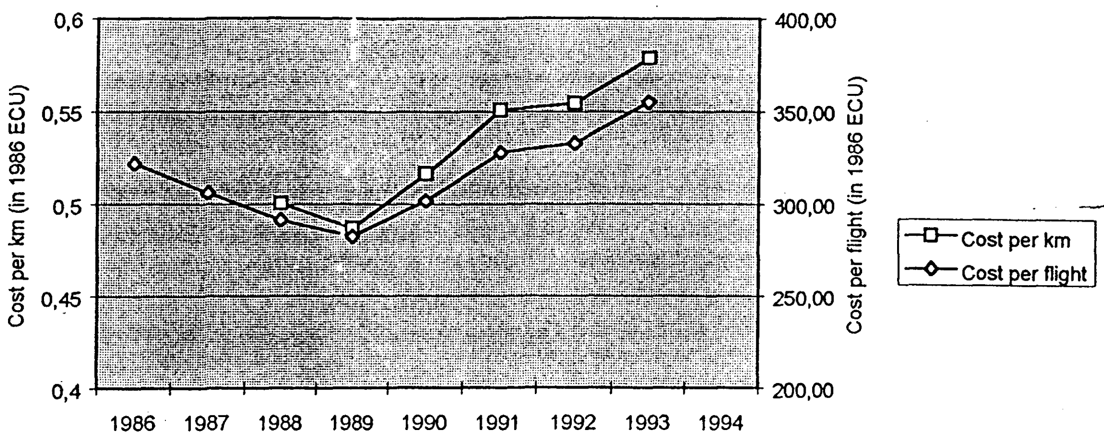
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Actual Unit Rate (ECU)	na	48.54	46.74	46.08	47.45	53.72	57.83	58.84	62.64	na
Chargeable Service Units generated (millions)	19.22	20.37	22.31	24.33	25.95	27.22	29.41	32.74	34.27	36.28
	-	+5.99%	+9.48%	+9.06%	+6.66%	+4.89%	+8.07%	+11.32%	+4.6%	+5.9%
Exempted Service Units generated (millions)	1.83	1.88	1.96	2.01	2.15	3.00	2.06	1.10	1.11	1.01
	-	+2.80%	+4.06%	+2.43%	+7.10%	+39.50%	-31.21%	-46.84%	+1.03%	-8.5%
Total Service Units generated (millions)	21.08	22.27	24.30	26.39	28.10	30.22	31.48	33.84	35.38	37.29
	-	+5.7%	+9.1%	+8.6%	+6.5%	+7.5%	+4.2%	+7.5%	+4.6%	+5.4%

Over the past decade the number of total service units has increased at an annual rate of 6.5 percent, reaching about 37.3 million in 1994. If these figures are compared with the corresponding figures on kilometers flown, it is clear that the increase in service units is principally due to the growth of air traffic generally, whether seen in terms of kilometers flown or the number of flights ; while the influence of aircraft weight has remained constant.

4.6. Efficiency issues

Air Traffic Control Services are operated at present as monopolies. Services are provided and controlled by single organisations in each state. As a result, as with many public services, the main motivation for the management of Air Traffic Services has been technical efficiency. However, the need to provide services to an ever-increasing international air traffic market has pointed up the fact that this imperative, which derives from national considerations, does not necessarily match the idea of a common European service functioning as if it were provided by a single unified system.

Figure 4.7. - Average cost per km and per flight in EURO/88



The issue of future investment in human and technological resources to achieve a harmonisation and integration of the different national systems, and the consequent effects for airspace users, inevitably raises the question of cost efficiency. What integration has been achieved so far enables us now to compare the different national systems in terms of the management and organisation of ATC centres. Such a comparison could well suggest that there are opportunities to reduce costs further.

European Air Traffic Control Services have very varying unit costs. As we have seen, the biggest differences are in staff and operating costs, which are reflected in the different unit rates charged by various countries. To some extent, the causes of these disparities are differences in quantity and quality of the manpower and equipment required to handle air traffic. It is undeniable that the more complex traffic handling becomes, so the more properly-trained staff and sophisticated equipment are required. Other causes related to staff costs, and hence availability, are the high differences in salaries, other remuneration and social security contributions paid by different countries.

Looking back over the last ten years, productivity indicators of Air Traffic Services - in terms of unit costs per kilometer flown, and per flight, in terms of ECUs at 1986 prices - show a positive trend until 1989 followed by a decline in productivity after 1991 at an average annual rate of 4.3% (see figure 4.7.). This suggests that between 1989 and 1993 there were no economies of scale: while total traffic volume increased by an average of 5.4% per annum, the overall discounted cost increased even further, by an average of 10% per annum. This trend is expected to continue next year. Looking at national figures, for some countries this is likely to be even more pronounced.

These trends are not entirely explicable by technical or external effects (such as differences in labour and systems costs), which suggests that there may well be scope for further cost reductions. A recent study by INSTAR suggested that ATC efficiency could be improved to the tune of 600 million ECU a year (in 1993 cost terms), in the following ways:

- reducing the costs of support personnel (i.e. in engineering, technical, administrative and managerial functions);

- reducing the level of "other" costs reported to the CRCO (such as meteorological services, telecommunications etc); and

- improving controller productivity.

If such a cost reduction had been achieved in 1993 it would have led to a corresponding reduction in the average unit rate of charge in "EURO/88" countries of some 30 percent. The study also suggests that possible improvements in cost performance as a function of centre size should not be disregarded. Larger centres do not seem to be necessarily more efficient then smaller ones: the study concludes that the significant variance in costs between ATM organisations may well mean that any economies of scale are currently masked by differences in cost efficiency between different ATC centres.

BASIC INFRASTRUCTURE REQUIREMENTS

1. Introduction

This Appendix sets out the Community's priorities for investment in the fields of Communications, Navigation, Surveillance and Automation of ATM functions.

When preparing the ATM component of the Trans-European Transport Network and trying to make its mind on the priorities for Community action in this area, the Commission realised the need for a more focussed view on the kind of projects which would yield the best results in term of improving capacity and safety.

Accordingly, it decided to launch a study, in co-operation with EUROCONTROL to ensure consistency with the CIP, aimed at identifying by mean of a multicriteria analysis the most promissing avenues for Community funding. This study, by analysing the Member States' investment plans, has identified three broad guidelines for action within which short term expenditure (up to 1997/98) can be coordinated with longer term spending (until 2000 or 2001). These guidelines are as follows :

- to improve the continuity and quality of surveillance in Europe,
- to improve the coverage and quality of the communication system,
- to improve the interoperability of ATC systems and the automation of operational coordination.

These guidelines have been further refined and broken down into two kind of project groups :

- "short-term projects", to bring on stream equipment available today and/or to apply common specifications already drawn up. This is a matter of supporting individual countries in their work to modernise their infrastructure,

- "medium-term projects", based on specifications still being drawn up which have yet to be validated by experimental equipment but which should become commercially available in the next few years. Here, the Community's role is to support the operational validation activities and the work being undertaken to prepare these new technologies for deployment by the year 2000.

It has to be underlined that the terms "short-term projects" and "medium-term projects" are used from a technical point of view to designate respectively short-term technologies implementation and new technologies pre-operational validation. From an investement point of view it is obvious that investment in "medium-term projects" should start very early in order to prepare in good time for the deployment of those technologies by the year 2000.

In addition, steps must be taken to create a European component for the global navigation satellite system which, in January 1994, the Community decided to make one of its priorities.[1]

2. The basic infrastructure for Air Traffic Management

2.1. Communications

Improving communications between pilots and controllers and between the controllers themselves will obviously improve capacity and safety by reducing the risks of misunderstanding.

For short-term projects, the Community's objective should be to help improve the coverage and quality of the existing analogue RT network. This means, in order of priority :

- setting up new VHF receiving/transmitting stations, or upgrading existing ones;
- improving the RT ground environment and installating equipment for frequency management;
- preparating for the changeover to 8.33 kHz channel spacing.

For medium term projects, preparatory work should be put in hand towards setting up the Aeronautical Telecommunication Network (ATN). Examples of projects under this heading might be :

- pre-operational development of the ATN Europe, preparing the ground segment of the network;

- joint feasibility studies and experiments on the changeover from existing applications to an ATN architecture;

- common pre-operational validation work in particular on air/ground communications, which should help to alleviate R/T overloads as well as controller's workload ;

- the development by industry of pre-operational products and ATN services.

In association with this pre-deployment joint activity, individual countries should take concrete action to introduce elements of the ATN from 1998/99.

[1] COM(94) 238 final, 14.6.1994.

2.2. The European component of a GNSS

When the 29th ICAO Assembly adopted the CNS/ATM concept it was recognised world-wide that new technology could improve the capacity of the air transport infrastructure. Studies and experience acquired with the US military GPS demonstrated that a space-based navigation system can also be of benefit to all other modes of transport. Particular benefits for the aviation sector will come from greater accuracy in position determination; and the ability to receive positioning signals over remote areas such as oceans and desert regions.

The European Commission therefore decided to support the implementation of a global navigation satellite system.

A Communication was adopted in June 1994[2] in order to define a way ahead for Europe. The Ministers of Transport fully supported the initiative of the Commission and adopted a Resolution in December 1994[3]. The European Parliament also underlined the need to take action on this[4].

The European Commission, EUROCONTROL and the European Space Agency have established a Tripartite Group to coordinate activities of the three organizations within the framework of a European Satellite Navigation Action Programme. This programme comprises two parallel elements :

- the implementation of the European Contribution to the first generation of Global Navigation Satellite System (GNSS 1) to enable users to gain early benefits from existing military satellite systems (GPS, GLONASS) through the setting up of civilian wide area and/or local area augmentation, the latter being needed for precision approaches and increased navigational accuracy, thus making possible new or reduced separation standards and increased ATC capacity.

- preparatory work needed for the design and organisation of the second generation Global Navigation Satellite System (GNSS 2) for civil use.

The ultimate objective of the European Commission is to contribute to the implementation

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2 COM(94) 248 of 16.6.94

3 JO n° C 379/3 du 31.12.1994

4 Cornelissen Report 30.11.1994

of a global system that can be certified as the sole means for all phases of flight. It is widely recognised that GNSS 1 may only be a transitional step to that goal.

The Tripartite Group has already assembled budgetary provisions for the implementation of a European contribution to GNSS 1[5] : this budget will enable the Initial Operational Capability (IOC) phase to be undertaken, based on a limited ground infrastructure. As well as those technical developments, work has still to be done on defining the requirements for an institutional framework, for service provision, system operation, certification, liability, etc.

Early benefits for the Air Traffic Management sector will therefore only be effective if :

- resources are made available to enable the implementation of the Full Operational Capability phase to be implemented. The potential for joint ventures between public and private bodies should be explored;

- an appropriate institutional framework is adopted to provide the necessary legal instruments for certification, financing and exploitation of the IOC phase. The Commission has already set up a High Level Advisory Group with representatives of the national governments and all other relevant participants in order to flesh out such a framework.

2.3 Surveillance

The extent to which surveillance is continuous, and of a high quality, has an obvious impact on:

- capacity, in as much as uniformity of surveillance facilitates the reduction of separations, especially at frontiers between national systems, where differences in performance levels have created unnecessarily large margins;

- safety, to the extent that greater precision allows a swifter detection of possible navigation errors.

For the short term projects therefore, the aim of Community action should be to encourage the establishment of a comprehensive monitoring network which meets appropriate quality standards (that is, those achievable with monopulse secondary radars). This means, in descending order of priority :

- setting up new monopulse radars, to provide total coverage

- adapting existing interrogators to monopulse technology, and,

5 EC participation comes from the Trans European Transport Network and the 4th Framework Programme.

- bringing existing monopulse radars into line with the new surveillance standards.

For the medium term projects Community action will aim to develop pre-operational validation and support measures in connection with the deployment of the new technologies (Mode-S radar and ADS) . The broad thrust of this will be as follows :

- technical and operational experiments to do with Mode-S, starting with the core area; and preparatory measures for its deployment (such as revising radar network diagrams and coverage charts);

- setting-up an infrastructure for the retrieval of ADS data in the North Atlantic, the Mediterranean and the Scandinavian countries, and the integration of ADS data in surveillance servers;

- operational assessment of the effects of reducing vertical separations, particularly over the North Atlantic.

2.4 Automation of operational coordination and new Data Processing Systems

Action in this area covers projects designed to increase the automation of operational coordinations between controllers, and measures to ensure better integration and automation of radar data and flight plan data processing systems.

Although appearing less obvious, the potential contribution of automatic data exchange services in boosting capacity and improving safety is perhaps more important than those of all the other improvements already mentioned. For instance, the replacement of voice communication links between controllers by a system of automatic data exchange reduces the controller's work load; and the effects of this in terms of increasing the productivity of the controllers - although difficult to measure at this stage - could be considerable.

For short term projects, Community action should focus on the development of the national data exchange networks, their interconnection and the automatic distribution of the various types of ATC data (radars, flight plans and coordination messages). Possible projects could include:

- setting up or extending terrestrial data networks, based on international standards (X25, ISDN, etc.);
- installing the hardware needed for the interconnection of these networks;
- installing network management systems to enhance the operational availability and efficiency of the service provided;
- implementing generic application protocols (X400, FTAM, etc.) and/or transport protocols in support of specific automatic data-exchange applications between the computers of ATC centres. In certain cases, this may mean that flight-plan processing computers still in use at certain ATC centres have to be replaced.

Priorities for action - in descending order of importance - are to set up:

- transnational connections,
- national networks or data links;
- networks needed for the exchange of radar data.

For medium term projects, Community involvement will concentrate on the integration of the Radar Data Processing Systems (RDPS) and the Flight Data Processing Systems (FDPS) within a distributed data base structure. On the technical side, this will seek to:

- implement RDPSs which comply with EUROCONTROL specifications for the processing of radar data;

- implement a new FDPS based on common functional specifications;

- improve the degree of correlation between FDPS and RDPS.

In view of the complexity of the systems under consideration and the need for a common approach to the development of new-generation RDPSs and FDPSs, the Community will give priority to supporting pre-implementation measures. Possible examples of such measures are :

- feasibility studies and other necessary measures, such as the development of prototype systems, for a common European approach to the new generation of FDPSs;

- feasibility studies and other essential measures to do with adapting ATC centres to enable them to use the RDPS specifications proposed by EUROCONTROL;

- studies on adapting pilot surveillance systems to the needs of Mode-S.

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RESEARCH AND TECHNICAL DEVELOPMENT (RTD) ACTIVITIES FOR AIR TRAFFIC MANAGEMENT.

1. Introduction

The identification and planning of RTD activities in the field of ATM in Europe is a process involving many interested parties, national administrations, research centres, universities and systems manufacturers.

The concepts for the future ATM environment developed within the ICAO/FANS group, which injected a new way of thinking in this field, addressed heavily the use of satellites, particularly for communication and navigation purposes. This led EUROCONTROL and then also European Space Agency (ESA) to include in their plans new subjects for RTD activities for ATM improvement.
With the spirit of supporting the ICAO/CNS Concepts the Commission services being involved under different titles in ATM RTD, started the ECARDA[1] initiative with the primary objective to coordinate RTD activities aimed at developing, evaluating and demonstrating new operational concepts based on advanced ATM functions and technologies so as to build the future European ATM system.

2. The future system

The future system is intended to be a well-understood, manageable, cost-effective and dynamic system that keeps pace with user needs for safety, capacity and efficiency as well as environmental requirements. This future system will be characterised by :

a. improved internetworking between elements of the system regardless of their physical distribution (distributed system);

b. an increased degree of automation, providing system users and service providers with increased efficiency through enhanced interfaces;

c. the flexibility to provide appropriate capacity to match the changes in requirements resulting from the evolving traffic patterns imposed by the fluctuations of the demand.

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[1] ECARDA (European Coherent Approach for RTD in Air traffic management, SEC (94) 1475), an inititiave undertaken by the three DGs VII,XII, and XIII to define a coherent framework for RTD activities in the field of ATM

The ATM system can be broken down into its individual components and elements, as set out below, and the RTD activities are assessing the various options to establish their benefits and drawbacks to enable the future system configuration to be defined. Broadly, introducing new procedures and technologies should facilitate the integration of the Flight Management Systems on board aircraft and air traffic control functions in the ground; support all ATM planning levels from strategic-long term through to operational monitoring and tactical control; and speed up the introduction of improved airspace management.

2.1. Airspace Management

For airspace management, the application of area navigation (RNAV) techniques in ATM can be made as new aircraft navigation systems are introduced. This will allow the implementation of new route profiles, comprising for example parallel tracks, tubes, fixed and random routes, flexible, mixed or dynamic routes, which together with reduced separation criteria will increase the utilisation of airspace, thereby contributing to an expected increase in the ATM capacity. The airspace structure should be adapted in a dynamic and flexible way to prevent restrictions on traffic flow during peak times.

2.2. ATM Procedures

The definition of the preferred ATM procedures is a very important part of the system definition process and starts from the planning of ATM system capacity to meet traffic demand. A number of planning layers are envisaged with new roles being assigned to the operators, covering Airspace Management (ASM), Air Traffic Flow Management (ATFM) and Air Traffic Control (ATC) at centre level, taking account of the options of traffic segregation based on equipment fit, aircraft performance, reduced horizontal, vertical and/or time separation standards, autonomous aircraft, free flight, dynamic sectorisation etc. To expedite the flow of traffic, airport operations, including airlines systems, Advanced Surface Movement Guidence Control and Management Systems (A-SMGCS) and landside operations, have to be integrated into the ATM system.

2.3. Control Strategies

The design of the future ATM system depends heavily on how control is carried out and where responsibilities will reside. The task sharing between the automated system components, on the ground and in the air, and the human has to be addressed to establish how automated systems could help the work of air traffic controllers and to which extent they could take over functions presently exploited by the man. Suitable limits for the involvement of the available automation technology have to be worked out to ensure that safety requirements are always met. The division of responsibilities between pilot and controller could also change significantly. In particular, the operations in and around airports will be greatly affected by the introduction of new technologies which will enable a greater efficiency in traffic flow, but will also require a new assessment of human responsibilities.

2.4. Aircraft Systems

The future ATM system considers the aircraft as an integral part of the whole and will rely heavily on the aircraft systems fitted. Flight Management Systems (FMS) will have to be coupled with GNSS receivers and ATN routers to perform ADS functions, to compute the most convenient flight path, negotiate with the ground control and then comply with 4D contracts for those parts of airspace where this will be needed; but also to decide whether free flight can be carried out and, if so, where.

2.5. ATM Support Systems

As in the case of many other complex systems the future ATM system will have to cater for the processing of a large amount of data, in real time for some applications, over homogenous areas certainly bigger than today's national airspaces. This can only be achieved by the introduction of ATM Support Systems to gather, process and distribute the data for surveillance, flight planning, meteorological reporting and forecasting, civil/military information exchange, airport/ATC/Airline Operational Centre (AOC) interconnection and to support the necessary computer assistance (automation) tools.

2.6. Communications

Communications between the ground and the air in the future system will be characterised by the silent mode of data transfer, implying a diminution of the use of traditional voice communications: routine traffic would instead rely on data transmission (datalink) leaving voice conversations for non-standard or specific situations. Ground-to-ground communications will be through an Aeronautical Telecommunication Network (ATN) using Open System Interconnection (OSI).

2.7. Navigation

The development and enhancement of navigation systems is aimed essentially at obtaining the most cost-effective solutions to meet the levels of safety, integrity and performance necessary for aircraft operations particularly under the conditions of high traffic density within European airspace. It will start with the introduction of Area Navigation, both Basic and Precision RNAV in 3D, followed by moves to 4D systems to obtain further gains in ATM system capacity and runway utilisation using Global Navigation Satellite Systems (GNSS) initially as a supplementary means of navigation, with the aircraft relying on on-board inertial or ground based navigation systems as a primary navigation system; later as a primary means, although there might be a need for a secondary navigation system for safety/redundancy reasons.

2.8. Surveillance

For surveillance, the objective is to integrate and distribute all means (primary and secondary radars and Automatic Dependent Surveillance (ADS)) through data fusion techniques, so that an improved picture results. The situation over the oceans and over terrain unsuitable for radar (where ADS based satellite systems are the only ones available) should be distinguished from other land areas where there will continue to be extensive radar coverage for the foreseeable future. The benefits of E-scan antennas deriving from military applications will need to be assessed.

2.9. Validation

The validation of new concepts and features for the Air Traffic Management System requires the performance of a number of exercises such as simulations and large scale, real time demonstrations of the envisaged functions and procedures, with various degrees of integration into a real environment. The validation strategy will plan, define and carry out the validation exercises to ensure that the technical components, resources and data required to run a validation exercise are available and work properly together to support an efficient implementation. It shall also integrate the analysis of human factors linked with the use of these new concepts and features and assess their acceptability in an operational environment.

3. The European Commission's RTD activities in the near future

The Air Transport part of the Transport RTD programme builds on results of the 2nd Frame Work Programme (EURET), and is mainly addressing ATM, but contains also tasks on air transport safety, environment protection and airport operations. Those related to ATM and airport management were defined in the framework of the ECARDA initiative with a total available budget of about 33 MECU.

As a result of the first Call for Proposal of the 4th F.P. in March 1995 for the part on ATM 13 projects were selected for which the Community will spend a total of 11 MECU. They address ATM functional architecture requirements, system modelling, simulation and overall validation , the human/system roles and the advanced automation.

The requirements and operational implications for Communication Navigation and Surveillance (CNS) will be covered in the next two Calls together with some other tasks covering further the domains of the first Call.

The tasks related to the airport operations are addressing airport design, management issues such as the different kinds of traffic flows within airports and the interface between airport management and control systems on the one hand, and ATM on the other. Modelling and simulation techniques will be developed, where appropriate, in order to define the system requirements and high-level functional architecture of an Airport Movement Guidance Control and Management System and will lead to a Demonstration exercise to validate the safety, capacity, environment and efficiency benefits. The research will include an examination of the impact of alternative operational strategies on the capacity and level of service of European airports. The proposal selection of the first Call led to 4 projects which will receive a total Community contribution of around 6 MECU.

The activities identified above will define the elements of the future system developing the appropriate components and technologies and starting the process of validating their contribution to the future system through demonstration.
This validation process of the overall system will continue into the 5th FP. The progressive implementation of validated elements of the future system into existing systems will bring progressive capacity improvements and could be supported amongst the initiatives envisaged in the Trans-european Transport Network (TENS-T).

Within the Industrial and Material Technology RTD Programme some 230 MECU will be utilized for Aeronautics activities of which around 25 MECU will be devoted to the improvement of the airborne side of the future ATM system.
In the March 1995 Call for Proposals at least three projects have amongst their objectives the definition of improved on-board systems to be integrated in the future CNS/ATM environment. For other projects the links with ATM are of lesser importance but will certainly be of relevance.

In the first activity it will be performed the development of a demonstrator for an Advanced Flight Management System compatible with future European CNS /ATM environment, including flight plan negotiation and 4D planning/guidance, the role of the crew as the manager of the airborne part of the future ATM system, the ovearall system integrity and user oriented functionality and cost-effectiveness.

Another project aims at the demonstration of a system enabling the safe continuation of aircraft operations in poor weather at a wide range of airfields with under-equipped runways. The solution is based on the use of emerging technologies like Enhanced Vision Systems (EVS) based on fusion of sensors and database, or Synthetic Vision Systems (SVS) based on precise positioning of aircraft and database.

The reduction of separations of aircraft in the landing phase to overcome one of the capacity limiting factors of the future ATM system is amongst the objectives on another RTD activity. In fact these separations are imposed by the hazards to the following aircraft created by the wake vortices of the preceding aircraft. This can be achieved by airborne multifunction equipment not only for wake vortex detection but also for dry windshear predictive detection, clear air turbulence, volcanic ash, gust alleviation, etc.

Amongst the projects that are less directly connected to the ATM environment it is worth mentioning one on advanced avionics aiming at defining and validating a demonstrator of a generic scalable computing architecture which would be used as a general purpose multi-applications computing platform into avionics providing i.a. CNS/ATM functionalities.

For the Transport Telematics sector of the Telematics Application RTD programme, about 60% of the budget will be committed as a result of the 1995 Call for Proposals which closed in March. The timetable for subsequent calls is not decided. It is intended to commit approximately 20 MECU for Air Transport projects in '95, with a further 14 MECU to be secured for those actions at a later date. Member States have been given an indication that some 25% of the total budget will be spent on Air Transport in the course of the programme.

Following the mentioned Call for Proposals , covering all topics of the Workprogramme, 14 proposals were selected for funding on Communications, Navigation and Surveillance, Airports,Controller Tools, Airborne Air Traffic Management Functions.

As in the case of the other Specific Programmes, the projects selected continue previous work funded through the second Framework Programme or through preparatory actions. The focus is on the provision of surveillance data through the integration of communications and navigation technology and experimentation with satellite navigation systems. The use of two-way data links and the integration with the Aeronautical Telecommunications Network are addressed as well as the experiments with the use of self-organising TDMA. Application of communication, navigation and surveillance technology to presently unserved airspace is also considered. The development of GNSS-1 is supported in multimodal projects. These demonstrate the exploitation of GNSS-1 by various user segments, including aviation and the possible transition to GNSS-2.

Within the Airports domain the intention is to obtain a demonstrator of an advanced surface movement guidance and control system, improving traffic flow at airports. Projects currently supported represent partial solutions, addressing one a guidance system and protection against intrusion, while the other will investigate the problems of surveillance data fusion at airports.

When addressing the Controller Tools several different aspects of the controller's task are considered in attempts to improve traffic handling. A task closely related to the airports work described above, will provide tools to assist planning and management of ground movements, while another will similarly support the tower and en-route controller.

The airborne functions will become relatively more important in future air traffic management systems and the development of airborne air traffic management functions is covered.The possible integration of future airborne collision avoidance systems and ground-based short term conflict alert is also addressed.
Within the ECARDA context, future work in Transport Telematics will seek to complete the airports systems demonstrator, improve airborne situation awareness and explore the need for a next generation of navigation satellites (GNSS-2). Further work will also be done on overall system architecture and the possible user benefits to be obtained from increased integration of traffic management, self-organising TDMA and other communications, airport and airline operational systems.

Conclusions

The outcome of the research will support pre-normative, pre-legislative activities, leading to international standardisation and prepare the implementation of the operational system satisfying user needs for safety, capacity and efficiency as well as environmental demands.

The RTD activities mainly performed by consortia of different organisations (industry, research centres, university, airlines, etc.) coming from all European Member States to further the definition of the future ATM system, will bring improvements through the cross-fertilisation of different European working styles and environments, resulting in an overall increase of technical knowledge and awareness, forming a solid background to face the world-wide competition, not only for industry, but also for other actors performing research activities which more and more need to be on the "leading edge".

The efforts undertaken following the ECARDA initiative that led to the RTD action in the 4th Framework Programme will have to be carried on and improved by means of the above-mentioned continuous co-ordination process, having Member States directly involved to monitor and advise, together with EUROCONTROL, in planning following phases.

Three main strands for action can be identified as a result of the monitoring, advising and planning functions : indication for further RTD action, selection for RTD results to be put into operation, with the resulting infrastructure projects or standardization activities.

ISSN 0254-1475

COM(96) 57 final

DOCUMENTS

EN 07

Catalogue number : CB-CO-96-104-EN-C

ISBN 92-78-01347-1

Office for Official Publications of the European Communities

L-2985 Luxembourg