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ASPECTS OF AIRSPACE EVALUATION

ASPEKTY VYHODNOCENÍ VZDUŠNÉHO PROSTORU

DIPLOMA THESIS
DIPLOMOVÁ PRÁCE

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ABSTRACT:

Thesis presents description of the air traffic safety, efficiency, permeability and capacity. Those aspect are further used to suggestion of airspace evaluation and safety, which occur during almost all phases of the flight.

ABSTRAKT:

Diplomová práce se zabývá jednak popisem stavu letecké dopravy a to zejména co se týče její bezpečnosti, plynulosti, propustnosti a kapacity. Výše uvedené je poté zhodnoceno v části věnující se aspektům nebezpečnosti vzdušného prostoru v jednotlivých fázích letu.

KEYWORDS:

ATM, ATC, ECAC, safety, capacity, delay, air traffic/airspace flow and capacity management, EUROCONTROL, airspace, classification, ATM 2000+ strategy, phases of the flight, separation.

KLÍČOVÁ SLOVA:

ATM, ATC, ECAC, bezpečnost, kapacity, zpoždění, uspořádání a řízení toku letového provozu, EUROCONTROL, vzdušný prostor, klasifikace, strategie ATM 2000+, fáze letu, separace.

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AFFIDAVIT

I declare that I have been acquainted with instructions for the final thesis elaboration and that I have created the entire thesis "Aspect of Airspace Evaluation" only by myself using the literature stated in bibliography list.

Brno, 12.10.2008

Signature:…………………………………….……….

CONTENT

1. INTRODUCTION

The air traffic belongs to the youngest traffic branches. From the beginning of 20th century to the present, it skirt intense development, which is unmatched with other kinds of traffic. This fast progress caused that the airplanes are able to fly faster and carry much more passengers and load than any other traffic. In several decades, air traffic established as irreplaceable way of passengers, mail and some kinds of goods transportation on middle and long distances. We can say - it has a monopoly position in that.
Together with air traffic advancement, also safeguard and air traffic control systems are developing. The beginnings were in token of telegraphy and visual resources. Today's systems are based on cybernetics and ATM (Air Traffic Management). Also the pressure and work load are increasing, but the humans are still the basic unit in the entire process.

My work, which you are now holding in your hands, is getting on the situation, which is now in air traffic management and control and in airspace. It is intended to describe this situation, should describe detectors of dangerousness of the air space and should also afford the view to the near future.

This book is intended to those, who are interested in air space management structure and problems but also to those, who just want to know which "highways" they are moving through, when they are flying.

I hope you will find here what you were looking for and at the same time I hope you will enjoy it and find out some new information.

Brno, August 2008 Author……………………………………

2. HISTORY, PRESENT SITUATION AND NEXT STEPS IN EUROPEAN ATM SYSTEM

2.1 History and development

First let me give you some introduction to this problematic. Let us move little bit to the past to recognize how much and how fast the things were changing.
In the beginning of the 20th century, everything was quite primitive and easy. All what the pilot must know was the weather forecast. In the early days of commercial aviation, pilots flew visually. Separation was achieved by visually identifying other aircraft and avoiding them. The relatively slow speeds and limited numbers of aircraft made this an effective solution to the potential for collision. Moreover, as far more aircraft were lost to mechanical failure or pilot error than to mid-air collision, airborne separation was not a major issue.
Then later in the thirties, a system which enabled the connection between ground and the airplane was developed. This was possible thanks to space telegraphy. As traffic levels in the vicinity of airports increased an aircraft were fitted with radio instruments to facilitate homing to a location, the need to sequence arrivals and departures became more important. An aircraft would home to the overhead of the airport at different altitudes then commence an approach following approval from the airport controller.

Picture 1: In bad weather, airports sequenced arrivals

With the introduction of en-route navigation facilities and the rise in levels of commercial aviation, separation of an aircraft under instrument flying conditions became the issue. Procedures, based on time and vertical separation were introduced; however, in order for air traffic controllers to assess the risk of conflict and issue suitable avoidance instructions, aircraft were obliged to follow routes.

Later in the 1960-1970s the ATC becomes more automatic. New computerized framework is set. With these systems, the air traffic controller is able to control up to fourteen airplanes, while using older systems (based on radar) he was able to control only nine (without radar only five-six) airplanes.

Picture 2: ATC in year 1970

Picture 3: ATC in year 2000

However in the teeth of technical advance, the air traffic was still growing and soon ATM became unable to manage current situation, apart from future challenges…

In the beginning of the nineties (1983) the advice of ICAO set the FANS committee to solve these problems. Enunciation of this committee sounded:
"The present system of ATS (Air Traffic Services) is far to be perfect. This situation lead in many unrealizable needs of users. First of all it acts about a problem with delays of airplanes. It means, that the airplanes are not able to take off and land in accurate time. Also there are problems with using optimal trajectory of flight and with insufficient flexibility. Qualities and possibilities of modern on board systems can't be fully use and ATS are in general uneconomical.

FANS Conception
The FANS Committee finished investigation in year 1988 and find out, that a lot of things must be change. They build up a conception of future aeronautic systems (FANS or CNS/ATM).
The essence of this conception is development in basic ways:
- Implementation of new process ***ATM*** which introduce beside ***ATS*** (Air Traffic Services) also two new services – ***ATFM*** (Air Traffic Flow Management) and ***ASM*** (Air Space Management).
- Implementation of new conception ***CNS*** (Communication, Navigation, Surveillance).

	Present system	**ICAO system**
Communication:	VKV/KV voice	Data transmission via mode S
Navigation:	VOR/DME, ILS	RNAV, GNSS
Surveillance:	SSR mode A/C	ADS, SSR mode S

Table 1: Development of CNS systems

As traffic levels increased, more and more sophisticated air traffic control procedures were required, culminating in the widespread introduction of radar and radar-based separation techniques. However, the rules governing these procedures limited the number of aircraft considerably. To avoid overload situations for controllers, some form of strategic flow management was required. Over time, each state developed its own methods of restricting the flow of traffic in its airspace. Eventually, in 1996, the Central Flow Management Unit was established to provide an ECAC-wide flow management service.

Since 1996, the Central Flow Management Unit has been very effective in facilitating the increase of commercial aviation levels. However, the concept of flow management was independent of airspace design and management and was more focused on individual air traffic control sectors rather than the efficiency of the ATM network.

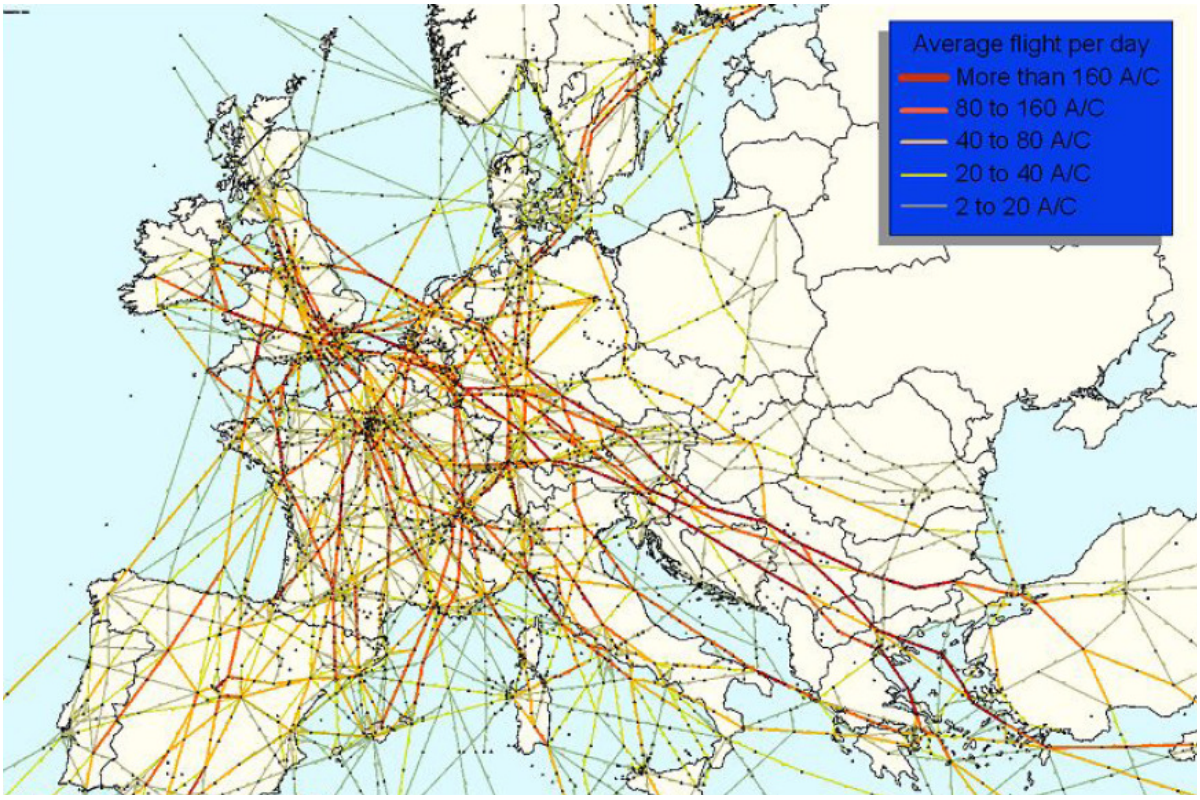
Current situation
Forecasts show that, compared with 2006, air traffic movements in Europe may double in the next 20 years.
The existing Air Navigation System and its sub-systems suffer from technical, operational and economic shortcomings. Despite the success of EUROCONTROL EATCHIP, and the measures already in hand to provide further improvements, the current system is unlikely to be able to cope with traffic increases of the predicted magnitude.
New advanced systems and concepts can offer potential improvements in terms of safety, environmental impact, efficiency and economy, provided that their implementation is based on a fully co-ordinated, harmonised, evolutionary and flexible planning process.
The ECAC Navigation Strategy has been developed to answer to this need. About this strategy I would like to talk later (page 13).

2.2 Facts and Figures

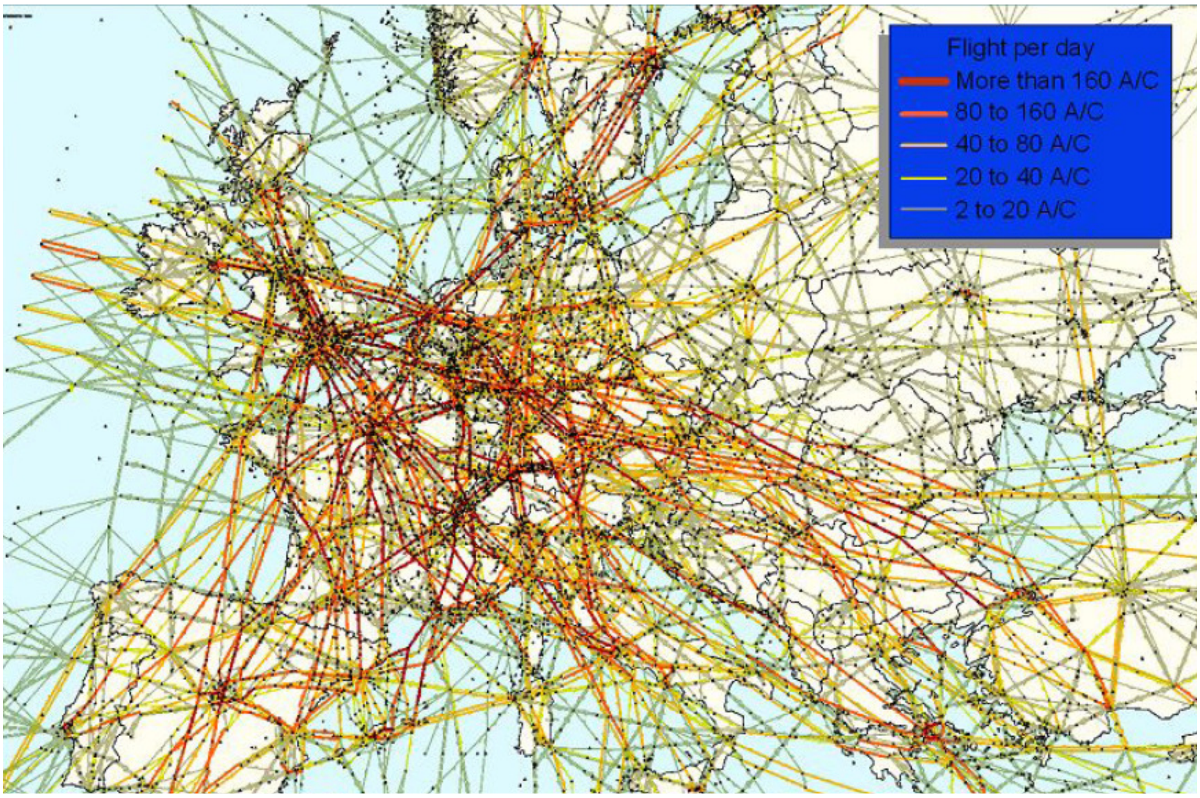
Data
Airline industry growth 1970-2003: 6,7% per year
Growth in selected areas (2002): Europe +3,7%
Middle East +8,7%
Asia – Pacific 6,2%
International freight traffic: 2003: +4,9%
2004: +7,2%

Forecast air transport industry for 2010: 2,2 billion passengers
44 million tonnes of freight

As you can see in following two pictures, the growth during some 15years was really huge. First, you can take a view of the air traffic situation above Europe in year 1989 and than some 15 years later. I thing, that the difference is more than perceptible.



Picture 4: Network evolution (1989)



Picture 5: Network evolution (2004)

Other tables and information about air traffic growth and evolution, you can find in ANNEX A.

In the end of this problematic just an overview of air traffic situation over the Czech Republic

Air traffic statistics - 2003 / 2006		
	June 2003	June 2006
Number of movements (Prague FIR)	39 476.00	67 199.00
Traffic growth		70,2%
Delay in average (ACFT in min.)	0,58	0,7
Number of movements (European FIR)	743 328.00	

Table 2: Air traffic statistics – June 2003

Number of movements at Czech airports				
	Prague	Brno	Ostrava	Karlovy Vary
June 2003	11 354.00	2 954.00	1 702.00	1 391.00
June 2008	17 018.00	3 838.00	1 962.00	730.00
Traffic growth	49,8%	29,9%	15,3%	52,5%

Table 3: Air traffic statistics – June 2008

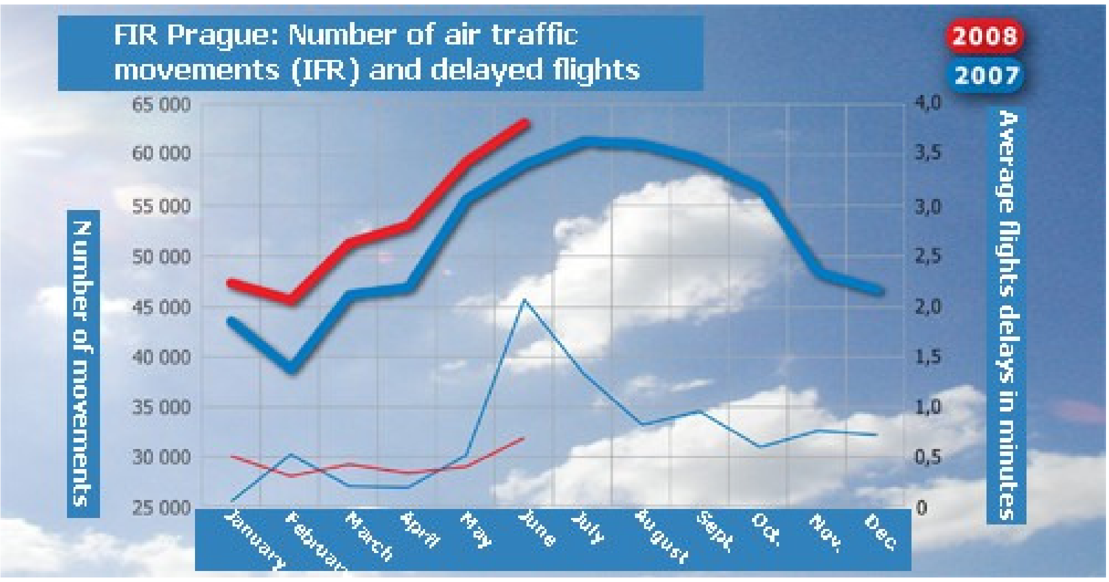


Diagram 1: Air traffic movements in Prague FIR – Czech Republic

2.3 The ECAC

2.3.1 About ECAC

Founded in 1955 as an intergovernmental organisation, ECAC's objective is to promote the continued development of a safe, efficient and sustainable European air transport system. In so doing, ECAC seeks to:

- harmonise civil aviation policies and practices amongst its Member States
- promote understanding on policy matters between its Member States and other parts of the world.

The ECAC is in fact a forum for discussion of every major civil aviation topic cooperating with ICAO, JAA and EUROCONTROL. It regards itself as the representative voice of pan-European civil aviation.
ECAC actively seeks and promotes arrangements, understandings and contacts with other regional organisations and States on a range of civil aviation issues of common interest.
ECAC issues resolutions, recommendations and policy statements which are brought into effect by its Member States. Under its auspices, international agreements have been concluded.
ECAC offers a forum for discussion and decision to European Ministers of Transport.
The Conference conducts, at regular intervals, international symposia and seminars.

2.3.2 ECAC Navigation strategy

The ECAC Navigation Strategy has been developed, with the users requirements being the main driver, to answer needs I described before (page 9). The main objective of the strategy is to provide a harmonised and integrated common framework which will allow a cost-effective, customer oriented evolution of the European Air Navigation System during the period 2005-2020. The evolution is described in terms of performance, functionality and corresponding infrastructure, taking due account of the principle of global interoperability.
The Navigation Strategy supports the operational developments proposed by the ATM 2000+ Strategy (later in my work) towards the implementation of a uniform European Air Traffic Management System. It is in line with the implementation of the ICAO Global Air Navigation Plan for CNS/ATM systems in ECAC.
The time horizon of the Strategy is split into three phases: short-term (2005-2010), medium-term (2010-2020) and long-term (2020 and beyond), and it is in line with other EUROCONTROL strategies.
The main strategic streams are aimed at:

- achieving a total performance-based RNAV environment with defined RNP values for all operations ECAC-wide;
- facilitating the implementation of the 'free routes' concept;
- supporting the continued operations of aircraft with lower capabilities as long as operationally feasible;
- implementing 4D RNAV operations to support the transition to a full gate to gate management of flight;
- supporting the continued operations of State aircraft, in line with the principles of the overall ATM 2000+ Strategy;

- providing positioning and navigation data at the required performance levels to support the various applications in the ATM/CNS environment;
- ensuring a judicious employment of the space-based infrastructure and a rationalisation of supporting ground-based infrastructure for all phases of flight, thereby ensuring the transition to GNSS, in line with ICAO recommendations.

Advances in Navigation functionality will enable improvements to be made in airspace design (structure, sectorisation, associated route network, applicable route spacing, separation minima and responsibilities, etc.), and will provide a high degree of flexibility for aircraft operations. Ultimately, with the support of appropriate ATM tools, operators will be able to conduct their flights in accordance with preferred trajectories, dynamically adjusted, in an optimum and cost-efficient manner.
The Navigation Strategy recognises the emergence of satellite technology and its future role in the global navigation environment. However, it is expected (based on current knowledge) that the rate of technological development of the system and the time needed for the resolution of institutional limitations will result in the need for a ground-based back-up system for GNSS for the foreseeable future for all phases of flight.
The Navigation Strategy aims to achieve a harmonised evolution of the overall Navigation System. In the framework of this strategy States may give preference to one implementation option or another in order to reflect sub-regional and local differences and to provide tangible and early benefits to the users. The availability of benefits should encourage the agreement and commitment of the users to the implementation plans. Furthermore, it will help the smooth transition to new systems and will minimise the period when support of both existing and new functionality will be necessary.

2.3.3 ECAC States

ECAC covers the widest grouping of Member States of any European organisation dealing with civil aviation. Currently it is composed of 44 Member States:

Picture 6: ECAC Member states

2.4 The Single European Sky

History

The idea of a single sky for Europe is one of long-standing. Indeed, EUROCONTROL was created in 1960 for the express purpose of creating a single upper airspace by its six founding member states. This purpose was only partially fulfilled at the time – but the idea remained a tenacious one.

Over the last decade, air traffic has grown by more than 50%. Europe now has close to 8.5 million flights per year and up to 28,000 flights on busiest days. Even so, airspace capacity has been increased by 80% since 1990.

These results are good but the growth of traffic is set to continue. EUROCONTROL expects that today's traffic will have doubled by 2020 as I said before. Current systems, with ongoing improvements, should be able to handle this increased load until the middle of the next decade. After that, more radical measures are called for in order to avoid serious congestion.

The Single European Sky initiative is confidently expected to lay the foundations of a unified system which will be able to cater for the anticipated growth.

The Single Europe

Europe eliminated frontiers on the ground with the 1985 single European market. It dismantled economic frontiers with the 1990 economic and monetary union. It is a view widely held that borders in the sky should not exist.

In spite of much effort to modernise and streamline it, Europe's air traffic management system remains safe but fairly costly. It is also hampered by heterogeneous working practices and constrained by air route networks which, in the main, are based on national borders and not air traffic flows.

The Single European Sky initiative puts forward a legislative approach to solving the issues that currently affect air transport as well as enabling ATM to cope with future demands.

Unified ATM

The Single European Sky launched by the European Commission was drafted with the following objectives:

- to restructure European airspace as a function of air traffic flows, rather than according to national borders;
- to create additional capacity; and
- to increase the overall efficiency of the air traffic management system.

The European Commission's ATM legislative package of four regulations covers the essential regulatory elements to be developed in order to achieve a seamless European Air Traffic Management System. They are:

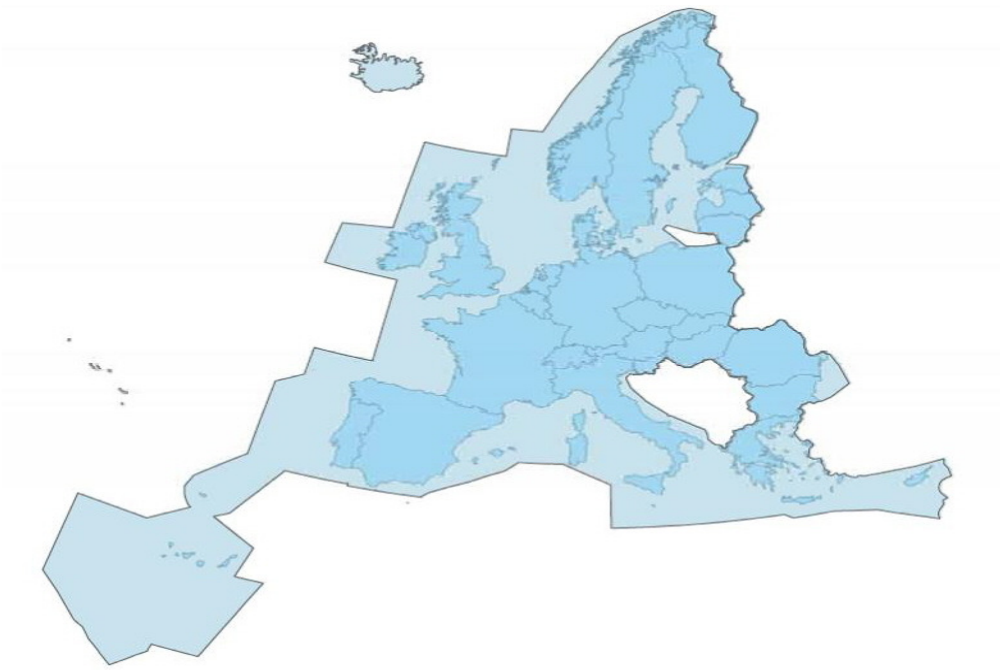
- A Framework for the Creation of the Single European Sky.
- The Provision of Air Navigation Services.
- The Organisation and Use of Airspace.
- The Interoperability of the European Air Traffic Management Network.

EUROCONTROL has considerable expertise and experience in these fields; expertise and experience which will be applied to help make the Single European Sky become reality.

Following the accession of the European Community to EUROCONTROL in October 2002, the European Commission - representing the European Community - will have the same rights and obligations as any Member State. It will coordinate the position of the EU Member States in those matters for which the Community holds competence (research and development policy, standardisation, trans-European networks, Single European Sky).

At the end of last year (2007), EUROCONTROL and the European Commission signed a Memorandum of Cooperation to enhance their synergy in five areas of cooperation:

- implementation of the Single European Sky;
- research and development;
- global navigation satellite systems, including Galileo;
- data collection and analysis in the areas of air traffic and environmental issues;
- international cooperation in the field of aviation.



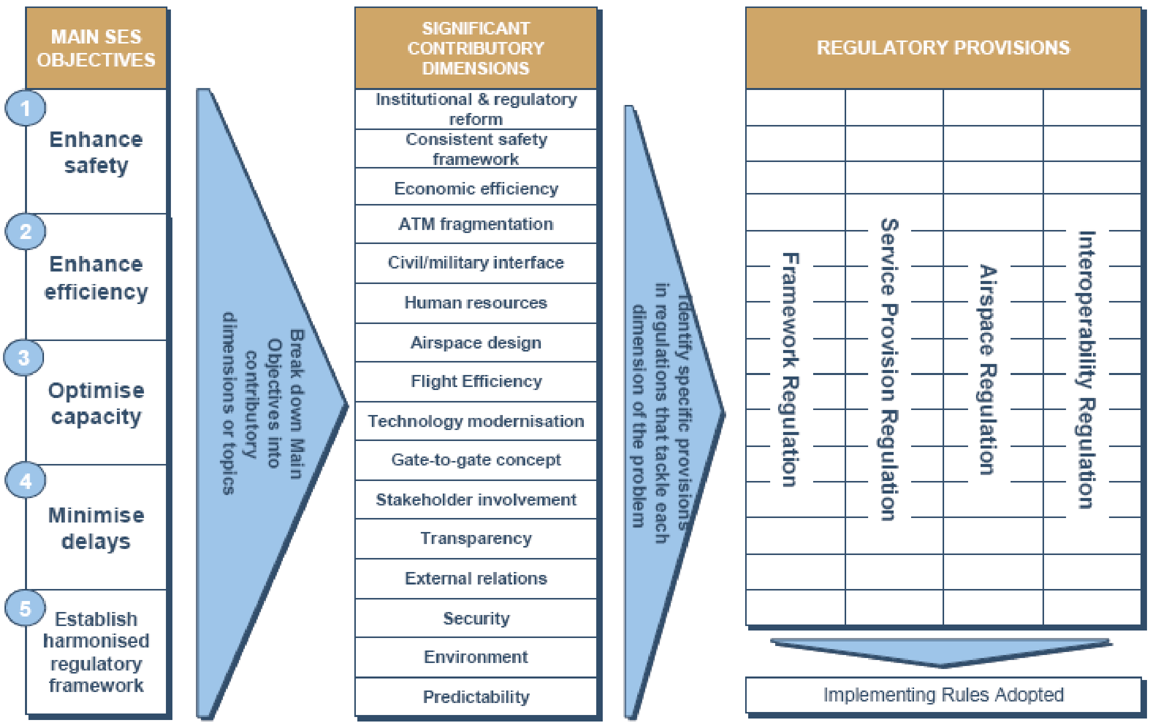
Picture 7: Single Europe – Single Sky

Objectives

- The project of European commission started in year 2001
- Aims topping by join European transport policy (European traffic network)
- Fundamental reform of air traffic control system in Europe
- Answer to air carriers and passengers requirements

Principles

- Enhancement of European airspace capacity and permeability for all users
- Maximization of safety and quality air traffic services; minimal time of delays
- Integrated upper area airspace over FL 285
- Building up functional blocks regardless of state borders



Picture 8: European integration of ATM – current situation of Single European Sky

3. SAFE, OR ECONOMIC AND WITHOUT DELAY? BOTH!

The title of this section can maybe sound like a science-fiction. But nothing can be farther from the truth. That is the main problem and the key figure which everybody is trying to solve or change into reality. Of course when we are talking about safety we are always trying to do our best to make flying as safe as possible. Almost everybody knows, that flying is the safest way of transport. So it happens, that if we have very safe flying we also wanted to have economic and fluent flying. But is it possible at all? Which are the main problems of combining those three aspects?

What is the problem?

1. Fragmented authority:
    - ICAO
    - EUROCONTROL
    - European Commission
    - JAA
    - EASA
    - NATO
    - National Governments
    - National Regulators
2. Nationalistic Approach:
    - Maintain national service provider (at all costs)
    - Maintain national industry
    - Support national carrier
3. Speed of action:
    - CFMU - Decision (Oct 1988)
      - Fully operational (Spring 1996)
4. Airspace organisation:
    - Based on ICAO classification (A-G)
    - National decision
    - At least 38 different implementations within ECAC
5. Airspace management:
    - National activity
    - Airspace (routes, sectors, etc.) fixed 5 years in advance
    - Costumers have to work with pre-determined capacity
6. UAVs problematic

Conclusions:

- The limitations of the current ATM System
- The scope of future changes to European ATM
- The objectives of the EUROCONTROL ATM 2000+ Strategy

3.1 How safe is flying actually?

Yes, this is a really very good question, because there is no agreed objective method of measuring safety in ECAC.
Since 1945, ICAO has been publishing accident rates for accidents involving passenger fatalities (excluding acts of unlawful interference with civil aviation) for scheduled operations. The diagram below is based on these ICAO accident rates.

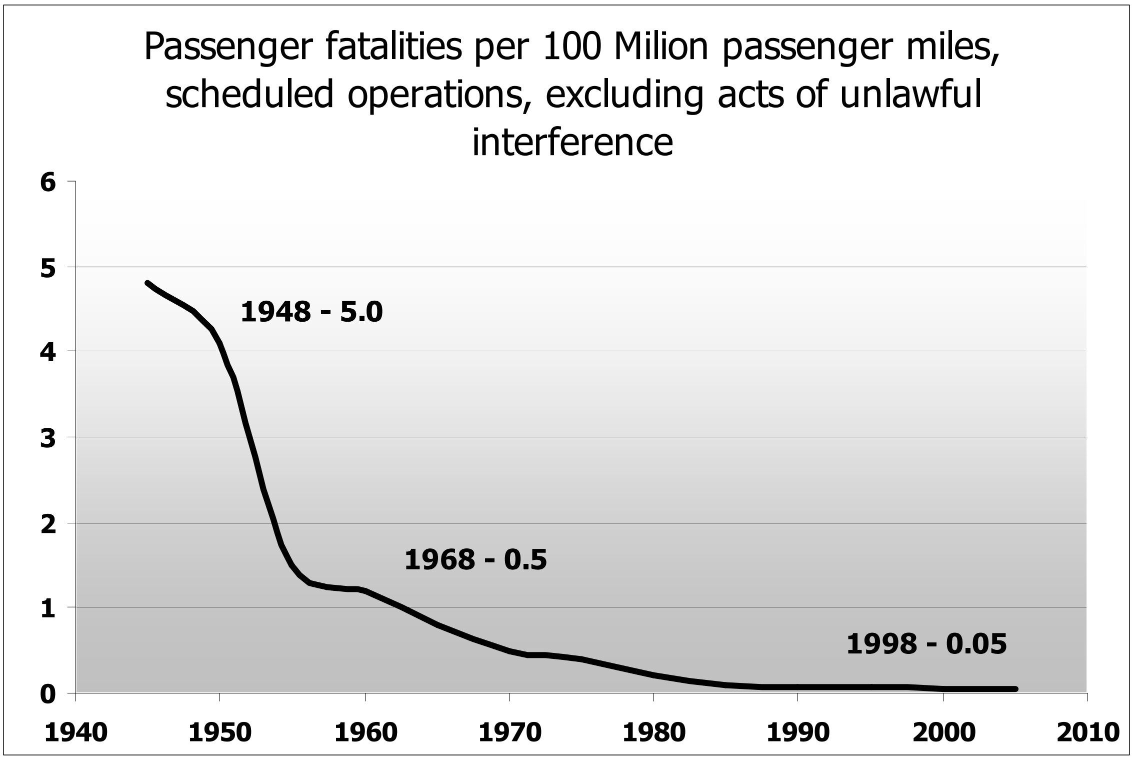


Diagram 2

The data show that the safety of aviation has improved from 1945 onwards. Based on the measure of passenger fatalities per 100 million miles flown, it took some 20 years (1948 to 1968) to achieve the first ten-fold improvement from 5 to 0.5. Another ten-fold improvement was reached in 1998, some 30 years later, when the rate had dropped below 0.05. The number of accidents is based on data obtained from the ICAO Accident/Incident Data reporting system. They concern fatal accidents to fixed wing aircraft with a maximum certificated take-off mass exceeding 2250kg.

It is generally known that flying is the safest way to move from point to point anywhere on the Earth. Notwithstanding this fact, many people grow afraid when an accident has happened, calling for remedy and an improvement of safety. And why do accidents happen exactly?

There are quite a number of factors which might cause flight accidents. Thanks to fast developments in recent decades, almost all regions of aviation suffer less from accidents caused by aviation technique. Technical progress however also raises complications of systems. Obviously just therefore the quantity of accidents due to human factors increases almost proportionally.

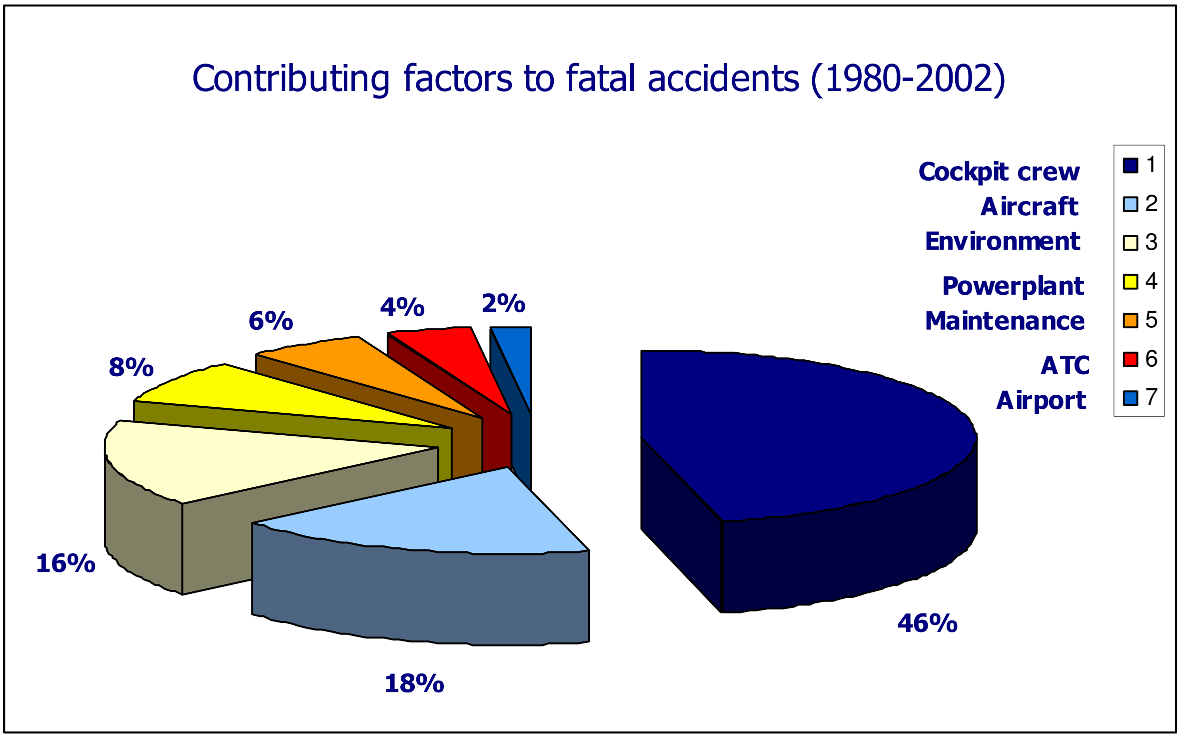


Diagram 3

Diagram 3 shows the importance of identified contributing factors over the period 1980 - 2002. Relative importance has been estimated based on the number of factors allocated for each factor group divided by the total number of factors identified. In total 832 factors were identified in 639 fatal accidents with known factors. There were 33 factors related to ATC. ATC contributes, in this context, to 5% of fatal accidents.

Reported ATM-Related Incidents

A categorisation of incidents reported is available and presented in the table 4 The values in parenthesis represents the number of reports providing data: in the table heading 2001(25) indicated that in 2001 aggregated statistics have been built up from 25 reports, and Runway incursion 223(16) indicates that 16 reports out of 4 have mentioned this type of indicator and the total sum from 16 reports is 223 incidents.

INCIDENTS	TOTAL				
	1999 (24)	2000 (25)	2001 (25)	2002 (27)	2003 (29)
Separation minima infringement	975(17)	987(20)	970(21)	824(20)	780(20)
Inadequate separation	78(9)	95(12)	167(18)	174(14)	176(16)
Near Controlled Flight Into Terrain(CFIT)	6(2)	1(1)	6(2)	23(5)	24(3)
Runway excursion by aircraft	2(2)	8(4)	10(6)	9(5)	9(6)
Aircraft deviations from applicable ATM regulations	7(2)	758(12)	1031(15)	1431(16)	1104(14)
Aircraft deviations from applicable published ATM procedures	30(6)	29(9)	104(13)	89(14)	219(10)
Aircraft deviations from ATM clearance	164(6)	623(16)	900(20)	1199(21)	979(19)
Unauthorised penetration of airspace	511(9)	488(13)	657(18)	1232(16)	1091(19)
Runway Incursion	56(13)	99(14)	223(16)	211(14)	351(14)

Table 4: Categorisation of Incidents Reported

3.1.1 ATM safety

The increasing integration, automation and complexity of the ATM System requires a systematic and structured approach to risk assessment and mitigation, including hazard identification, as well as the use of predictive and monitoring techniques to assist in these processes.

Errors in the design, operation or maintenance of the ATM System or failures in the ATM System could, through a decrease in safety margins, result in, or contribute to, a hazard to aircraft. Increasingly, more reliance and therefore a greater safety burden, is being placed upon all parts of the ATM System. In addition, the increased interaction of ATM across State boundaries requires that a consistent and more structured approach be taken to the risk assessment and mitigation of all ATM System elements throughout the ECAC States.

In addition, and in certain cases, the implementation of ESARR 3 (Use of Safety Management Systems by ATM Service Providers) also necessitates the provision of more specific requirements to be used.

Accordingly, a harmonised approach to the identification, assessment and management of risk is a necessary step in ensuring high levels of ATM safety across the ECAC area.

Safety Requirement

An ATM service provider shall ensure that hazard identification as well as risk assessment and mitigation are systematically conducted for any changes to those parts of the ATM System and supporting services within his managerial control, in a manner which:

- addresses the complete life-cycle of the constituent part of the ATM System under consideration, from initial planning and definition to post-implementation operations, maintenance and de-commissioning;
- addresses the airborne and ground5 components of the ATM System, through cooperation with responsible parties; and
- addresses the three different types of ATM elements (human, procedures and equipment), the interactions between these elements and the interactions between the constituent part under consideration and the remainder of the ATM System.

The hazard identification, risk assessment and mitigation processes shall include:

- a determination of the scope, boundaries and interfaces of the constituent part being considered, as well as the identification of the functions that the constituent part is to perform and the environment of operations in which it is intended to operate;
- a determination of the safety objectives to be placed on the constituent part, incorporating

Hazard Identification and Severity Assessment in ATM

Before the risks associated with introduction of a change to the ATM System in a given environment of operations can be assessed, a systematic identification of the hazards shall be conducted.

The severity of the effects of hazards in that environment of operations shall be determined using the classification scheme shown in ANNEX B; table B-D.

As there is no such scheme today as an accident/incident causation model, the severity classification shall rely on a specific argument demonstrating the most probable effect of hazards, under the worst case scenario.

Safety Regulation Commission (SRC)

It was established in 1998 and has since identified a number of priority tasks to be undertaken. Two of these are the "development of safety indicators" and the "identification of key risk areas where ATM has the potential to improve safety".

But in fact it was set up to harmonise ATM safety regulations within Europe with the aim of maintaining, and where possible improving, safety standards. In order to develop safety improvements, strategies and regulations, the SRC needs to establish the current risks posed by ATM in the ECAC region.

The SRU carried out study with the objective of providing the SRC with an overview of the ATM related safety data, which currently exist, as produced by third parties. The SRC does not however take responsibility for the results provided by other parties.

The report therefore only intends to compile existing results produced so far by third parties with regard to the;

- identified levels of ATM safety being achieved worldwide and in the ECAC region; and

- number and categories of identified ATM contributions to aircraft accidents and incidents that have occurred in the ECAC region in the last twenty years.

Accident Statistics Worldwide and Within the ECAC Region
The main existing sources are the Worldwide Aircraft Accident Summary (WAAS) established firstly by the UK CAA.

From the WAAS, a selection of fatal accidents were studied by the UK CAA. Figures regarding the number of accidents and fatalities during the period have been extracted from this study and are shown in ANNEX B.
When considering the number of accidents occurring worldwide, with the exception of accidents in the former USSR, the aviation world recorded 893 fatal accidents and 23,737 fatalities over the period 1980-2003 (Table B-E), or an annual average of 37 fatal accidents and 989 fatalities.
The worst years for numbers of fatalities appear to be 1985, 1992 and 1996, but of these, the highest number of accidents was found in 1996. There is neither a strong correlation between the number of fatal accidents and the number of fatalities, nor defined trend that would indicate an increase or decrease over time in the number of fatal accidents. No accurate regression has been found on which to base forecasts.
Another selection of accidents was provided by the UK CAA, based on the same sample, to indicate the situation in the ECAC area. In this timescale, 113 fatal accidents and 3,077 fatalities were recorded over the same period (Table B-F; ANNEX B). The average annual figures are 5 fatal accidents and 128 fatalities.

Summary
When flying, the human body is moving in unaccustomed fully dimensional space at high speeds. Many factors exert an influence on the human organism, examples being pressure and temperature changes, light, noise, vibration and over freight and others. At the same time, crew must serve many difficult tasks quickly and precisely. Failure of the human factor in these conditions often has as a consequence inception incorrigible damages.
Human factors play a decisive role in the construction of aeroplanes already. They have to be constructed with reference to physiological characteristics, needs and limits of the human organism.
Pilots in contrast to air traffic controllers are exposed to more biases, not only to stress. That’s maybe why overwhelming majority of mishaps happening in the air (better told by because of crew). On the other hand the profession of air traffic controller is more exhausting because of higher level of stress.

3.2 How expensive is delay?

Well delays are really very expensive – as you predicted. But first, before I show you real numbers, let me tell you bit about delay division. There exists:

- Air transport delay: delay calculated with respect to published flight schedules

- Arrival delay: difference between actual and scheduled arrival time
- Departure delay: difference between actual and scheduled departure time
- ATFM delay: delay at departure caused by ATFM regulations. Difference between CTOT (Calculated Take Off Time) and the last ETOT (Estimated Take Off Time)
- En-route ATFM delay: delay caused by En-route regulations
- Airport ATFM delay: delay caused by Airport regulations
- Reactionary delay: delay caused by late arrival of aircraft or crew

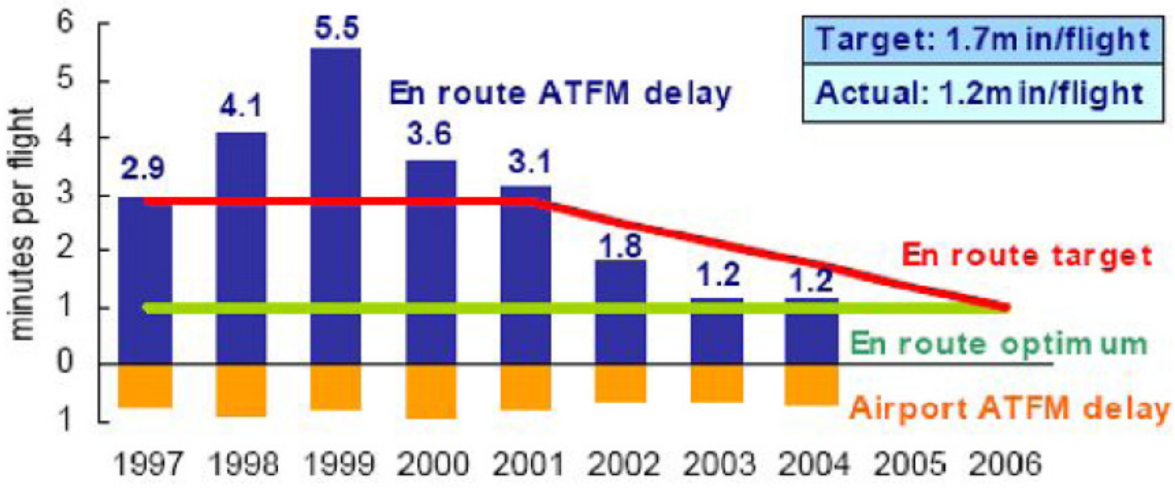


Diagram 4: Average ATFM delay per flight (Summer)

Departures: 28% delayed by an average of 45minutes
Arrivals: 40% delayed by an average of 55 minutes

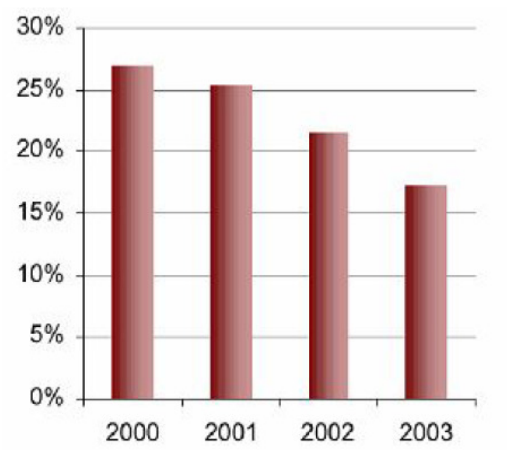


Diagram 5: Percentage of flights with arrival delay > 15min

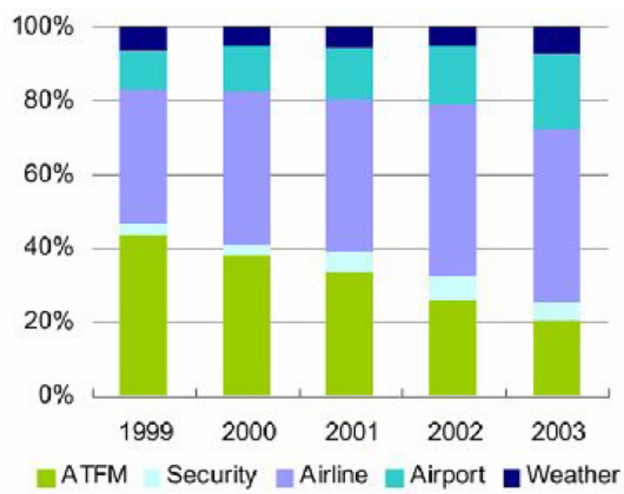


Diagram 6: Proportion of primary delay

Total ATFM delay costs: 800 million Euros
Delay costs for major airline operating from major European airport.

Annual arrival costs: 7.5 million Euros
Estimated costs per passenger for all delay:
20 Euros

As the numbers above reflects – delays costs forms indispensable part of "air traffic money". I think that satisfied airliner = satisfied passenger. All airliners want to minimize its costs. And that is possible by several facilities. For example fly best routes in best times, etc.
And when the airliners have small costs, they are of course happy and they can also offer the air tickets for smaller prices. Everybody are happy than – except, this is unfortunately not possible, off-other because of ATM.

Performance shortfalls and delays
But the question of delays in air transport is a complex one. More than 70 causes have been identified, of which ATM is just one of a number (airlines, airport, meteorological conditions, etc.). Given that the demand for air travel will continue to grow, both the number of flights subject to ATM delay, and the total ATM delay experienced, will increase unless there is a corresponding expansion in the capacity of the present ATM network, including that of the airports and their surrounding airspace.

Nevertheless, aviation is a dynamic process and it is not possible to eliminate all causes of delay entirely. Neither would it be cost-effective to build an ATM network capable of handling abnormal or infrequent peaks in demand. While it is therefore natural to plan the ATM system so that it still generates a certain amount of delay, the long lead-times needed to implement improvements mean that increases in ATM capacity have to be planned to anticipate the growth in traffic if delays are to be contained at, or below, economically optimum levels.

ATM is in essence a network using a number of resources of limited capacity for which the Airspace Users compete. To accommodate increasing levels of traffic demand, it has to evolve to make better use of scarce resources, or to generate more resources, or increase its use of resources that are less subject to congestion. As a result, ATM performance, is very sensitive to whether or not the network functions close to, or at, its congestion ceiling. ATM delays tend to grow exponentially when the network is approaching saturation. The preparation of future plans, and the consideration of what would need to be changed or improved, has to take account of:

- the potential performance shortfall that would develop if the network was not, or was insufficiently, adapted to the growing traffic demand;
- analysis of the causes of these potential shortfalls and when and where they materialise to help eliminate them as far as possible.

Several specific analysis methods are available or are being developed, including simulations, macro-economic modelling and analytical work. The work conducted so far, although it has not yet addressed all of the issues because of the complexity of the problem, leads to a number of converging results that:

- confirm the exponential character of ATM delays when accommodating increasing traffic at constant capacity;
- show how all improvements, current and past, progressively increased capacity, but have left a chronic overall under-capacity;
- show that, in Europe, en-route ATM is currently the root cause of a majority of the ATM delays, but that delays at and around airports are already an increasing fraction, and would grow more rapidly becoming predominant once en-route problems were solved;
- indicate that the optimum functioning point of the network in terms of costs is achieved when the capacity offered is slightly higher than demand, and that costs increase more rapidly when capacity is insufficient rather than more than sufficient. In periods of increasing traffic, this leads to a definite advantage in allowing capacity to grow ahead of demand;
- show that the situation at the ATC centres is not uniform; some still have capacity margins, while severe potential shortfalls are predicted for others;
- indicate that the further use of the technique of splitting sectors to increase capacity (although still a key for the shorter term and a technique that will accompany other improvements) will not accommodate future traffic demand, and that significant changes in ATM concepts are required to enable phased sector productivity gains (i.e. number of flights that an en-route sector would be able to manage) have to be achieved by 2015.

4. CZECH AIRSPACE CATEGORIZATION

The airspace all over the world is a really huge space. Many airplanes and flying objects are moving in it. The aviators very often like to say "The air is our ocean". But I think, this is more or less no more the truth. It is of course because of large aviation boom in last few decades. That is why the air space must be separated and straight layout.
Also the air space in the Czech Republic is separated - namely by horizontal borders to the classes, which are marked with letters. The airspace is divided into four classifications C, D, E, and G which equate with those recommended by ICAO. Airspace classified as C, D and E is controlled airspace.
Class C airspace comprises:
- TMA PRAGUE;
- airspace above FL 95 to FL 660.

Class D airspace comprises:
- CTR/TMA of all aerodromes with the exception of TMA
- PRAGUE;

Class E airspace comprises:
- airspace outside CTR/TMA above 1000 ft AGL to FL 95.

Class G airspace comprises:
- with the exception of CTRs the airspace from ground to 1000 ft AGL.

(Letters A to G are used in the world). For each of those classes straight rules are set. These rules determines e.g.:
- which type of flights is possible to operate in a given space (VFR x IFR)
- if, and which services are provided by ATC stations
- minimum meteorological conditions for VFR flights
- appropriate limitations of speed
- requirements for radio communication
- if it is necessary to hand in a flight plan

Farther, around the big airports there are definition areas called CTRs (Control Zone) TMAs (Terminal Manoeuvring Area) – by military airports with M – which means "Military" (MCTR, MTMA).
These areas are horizontally and vertically defined on air charts. The air space in these areas has characteristics of C class (TMA Prague) or D class (CTR and TMA the other airports).

CTR and TMA looks like a cake storied upside down: CTR is the smallest piece and stretched from the ground to 3000ft. (approximately 9NM around the airport). TMA is bigger in horizontal way, but its lower border is over CTR (it means 3000ft) and rise to FL65. Upper margin is generally at FL125, except Prague TMA (in Prague it is 145FL). The horizontal border is marked in the map and reached maximum 30NM from the airport.

Both CTR and TMA are not the circles indeed. They are figures which are defined by a points and archs around the radio beacons. Therefore it is necessary to study appropriate maps for familiarization.

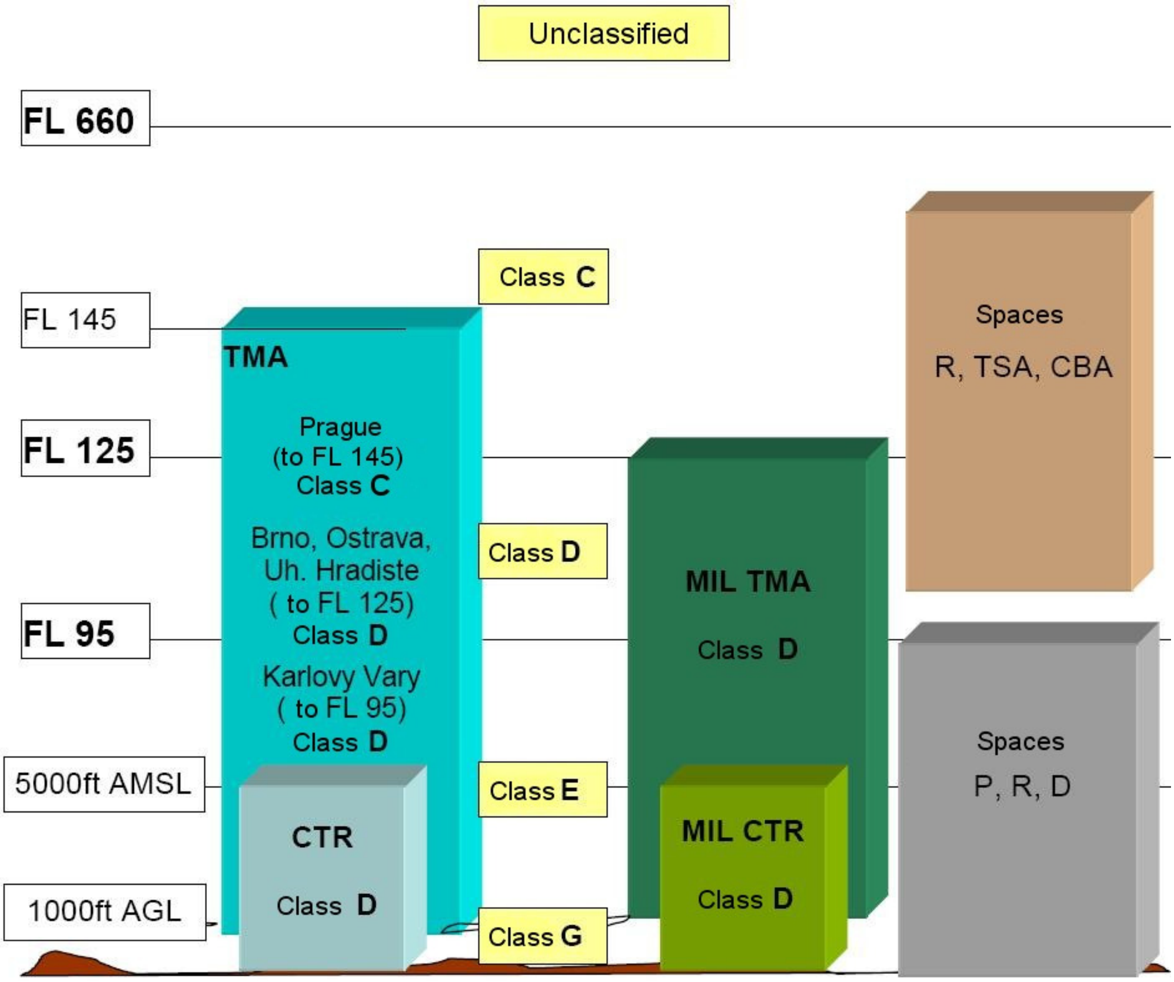
It si not possible to enter the TMA areas without agreement of pertinent ATC station (it can be APP or TWR).

For the IFR flights which are provided in C, D and E classes, the ATC service is offered. For the VFR flights this service is provided just in class C and D. And also the segregation must be managed by pilots themselves.

Over the Czech Republic there are also quite a lot of RA (Restricted Areas), PA (Prohibited Areas) and DA (Danger Areas). Some RA are then time selected (TSA – Time Selected Areas).

Class	**Margin**	**IFR**	**VFR**	**VFR with FP**
C	**over FL 125** **TMA Praque**	**Yes**	**Only to FL 200**	**Always over 1000 feet** **AGL**
D	**FL 85 – FL 125** **CTR** **TMA except Prague**	**Yes**	**Yes**	**Always over 1000 feet** **AGL**
E	**1000 feet AGL – FL 85**	**Yes**	**Yes**	**No**
G	**From ground to 1000 feet AGL**	**No**	**Yes**	**No**

Table 3: The air space classes and its characteristics



Picture 9: Czech airspace categorization

(More detailed picture you can find in ANNEX C)

Use of airspace of the Czech Republic
Use of airspace of the Czech Republic is carried out in compliance with the Commission Regulation (EC) No. 2150/2005 by which the common rules for the flexible use of airspace based on the original conception of FUA (below) are established and is further regularized by provisions §44, §46 Act. No. 49/1997 Coll. in Civil Aviation and Decree No. 108/1997 Coll.

FUA
The Flexible Use of Airspace concept (FUA) has been underway in the Czech Republic since 1996. The concept is based on the core principle of the airspace shared by all of its users, with flexible and temporary allocation of the airspace to the respective users.

5. AIRTRAFFIC FLOW AND CAPACITY MANAGEMENT

One of the major objectives highlighted in the ATM 2000+ Strategy (later – cap. 7) concerns the need to provide sufficient capacity to accommodate the General Air Traffic demand in typical busy hour periods without imposing significant operational, economic or environmental penalties under normal conditions. This strategy highlights that in its role definition ATFM should not be restricted to slot allocation mechanisms but should also be extended to the optimisation of traffic flow patterns and capacity management. The development of ATFM is therefore very closely linked to the improvement of capacity and safety and complementary to other Agency activities like Advanced Airspace Scheme (AAS) and Enhanced Flexible Use of Airspace. Moreover, this part of my work outlines the strategic steps envisaged to improve Air Traffic Flow and Capacity Management (ATFCM).

5.1 History

First thinking about air traffic flow management over the European continent appear in the year 1980. In this year it was obvious than more that it is necessary to plan and regulate the air traffic flow. The new EROCONTROL database was set. Except this database, national FMU (Flow Management Unit) established which started to organise air traffic flow in its own areas.

During the second half of the eighties it went beyond unto strong aviation resurgence. Therefore, the steps which were made showed as a wanting – if we are speaking about flow management. Especially in summer months it goes to surfeit of the air space which caused a lot of delays. In the year 1986 12% of all flights were more than fifteen minutes delayed. And by the year 1989 this number reached 25%.

But the problems with the air space capacity were caused not only by bad organisation and air space evaluation, but also by obsolete systems, insufficient radar footage and lack of practised controllers. This reality exemplifies the fact that fifty one control centre in Europe were using thirty one various computer nets, which made use of eighteen different computer types, working with twenty types of operating systems. So during the eighties new supranational centres are rising, including several controlling areas – FMU in London, Paris, Madrid, Rome and in Frankfurt.

5.2 ATFCM in Czech Republic

In the Czech Republic, flow and capacity management were provided by Prague controlling centre which was something like FMU in Europe. This system calculated the load over each of sector way points and compared it with hour capacity. The system was doing pre-tactical and tactical activities. This system was in order to the end of the nineties. In this time it was replaced by CFMU (Central Flow Management Unit) in Europe.

The density of the air traffic is increasing from the year 1993 across the world. Despite the fact that air traffic is growing, the delays are reducing. The average delay of each flight was reduced on the half from the year 1898. This represents better productivity of ATC (more than 50%).

The prognosis of air traffic growth, which you can see below, is based above all on EATCHIP (European ATM Harmonization and Integration Project).

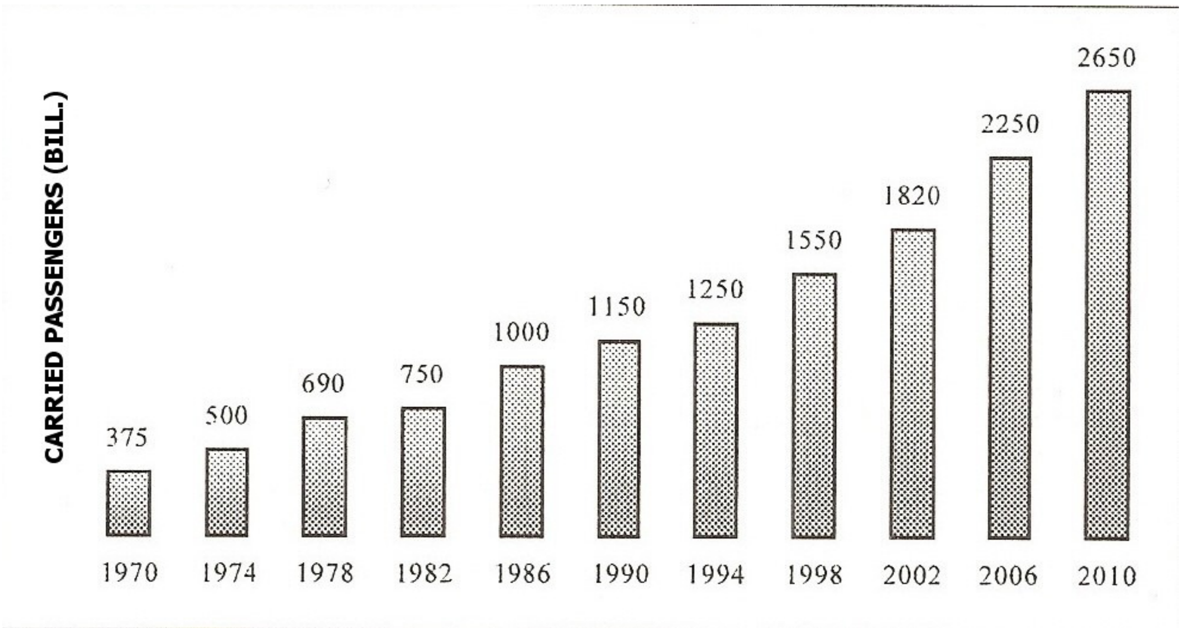


Diagram 7: The process of air transportation rising, from 1970 and prognosis to 2010

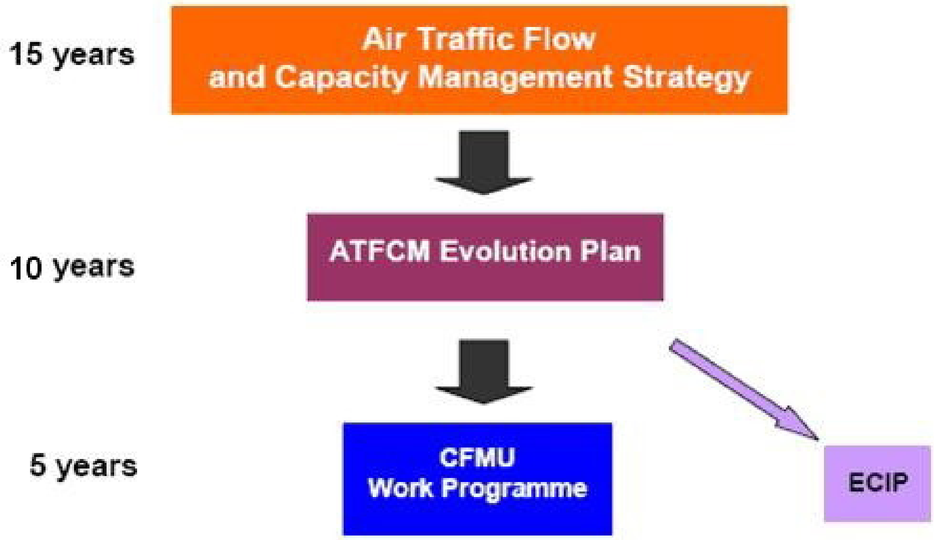
5.3 ATFM in general

Air Traffic Flow Management (ATFM) represents an important part of the complex ATM network and is covering with other domains (Airspace Organisation and Management, Airports, ATC Data Processing, Aeronautical Information), the entire range of elements to support the EUROCONTROL ATM 2000+ Strategy.

The Flow and Capacity Management Strategy is developed based on input from different sources:

- EUROCONTROL ATM 2000+ Strategy that provides the scope and the links with other domains strategies;
- The Single Sky draft regulations and their associated studies;

- ATFM operations and feedback from the ATFM actors;
- Research and Development performed on ATFCM.



Picture 10: Future development of CFMU

ICAO ATFM Definition
Definitions of ATM and ATFM have been adapted by ICAO in 2001 and are published in the PANS/ATM document:

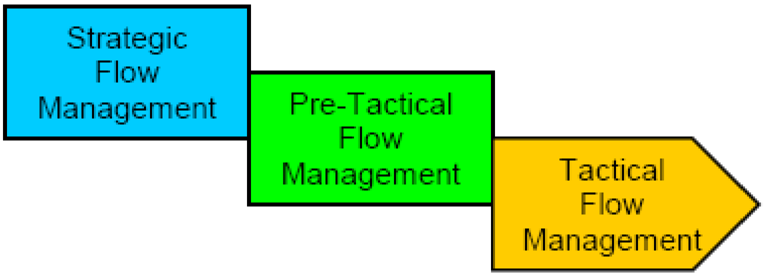
<u>Air Traffic Management:</u> The aggregation of the airborne functions and ground-based function (Air Traffic Services, Airspace Management and Air Traffic Flow Management) required to ensure the safe and efficient movement of aircraft during all phases of operations.

<u>Air Traffic Flow Management (ATFM):</u> A service established with the objective of contributing to a safe, orderly and expeditious flow of air traffic by ensuring that ATC capacity is utilised to the maximum extent possible, and that the traffic volume is compatible with the capacities declared by the appropriate ATS authority.

Current Air Traffic Flow Management
Responsibility for Flow Management within European airspace is invested in the centralised flow management function of the CFMU, which operates in close relationship with Airspace Users, "local" Flow Management Positions (FMP) at the different Air Traffic Control Centres (ACCs). These FMPs act as the interface between the CFMU and the ATC process, including local aerodromes. FMPs and airspace Users have on-line connection to CFMU systems, therefore have access to he same information as the CFMU.

5.4 ATFM Phases

Air traffic flow management has 3 phases:



Picture 11: ATFM Phases

Strategic Flow Management takes place between 18 months and a few days prior to the day of operation. This phase consists of analysing the evolution of the forecast demand and the identification of potential new problems and in evaluating possible solutions. The outputs of this phase are the capacity plan for the following year, the Route Allocation Plans and sets of other plans that can be activated as necessary during the next phases (e.g. contingency).

Pre-tactical Flow Management is applied during the few days prior to the day of operation. This phase analyses and decides on the best way to manage the available capacity resources and on the need for the implementation of flow measures (regulations or routings). The output is the ATFM daily plan (ADP).

Tactical Flow Management is applied on the day of the operation. This phase updates the daily plan according to the actual traffic and capacity. The management of the traffic is made through slot allocation and/or ad-hoc re-routings.

Airspace Management in the Czech Republic
Airspace Management (ASM) is treated in accordance with the strategy of ECAC states and their FUA Concept and some other documents.

ASM is applied in three levels:
- strategic
- pre-tactical
- tactical

Strategic ASM level
This level is provided by Civil Aviation Authority (thereinafter Authority) that makes decisions in agreement with the Ministry of Defence and according to the Regulation (EC) No. 2150/2005, Article 4.
Authority is obliged to perform the following tasks:
a) to ensure the overall application of the flexible use of airspace concept at a strategical, pre-tactical and tactical level;
b) to review users' requirements regularly;

c) to approve activities which require airspace segregation or restriction;
d) to define temporary airspace structures and procedures to offer number of different airspace segregation and route options;
e) to provide criteria and procedures for establishment and application of the adjustable lateral and vertical airspace limits required for alternative flight routes modifications and short−term changes of routes;
f) to analyze the national airspace structures and flight route network to facilitate flexible airspace structures and procedures planning;
g) to set specific conditions giving the responsibility for separation between civil and military flights to the air traffic services units or military control units;
h) to develop cross−border airspace use with neighbour states where needed by the air traffic and users' activities;
i) to coordinate its airspace management policy with neighbour Member States to deal together with the use of airspace spread over the national borders and/or the of flight information regions boundaries;
j) to establish and make available airspace structures to users in close cooperation and coordination with neighbour Member States if the airspace structures concerned have a significant impact on the traffic spread over the national borders and/or the flight information regions boundaries to ensure optimal use of airspace for all users throughout the Community;
and some others…

Pre-tactical ASM Level
This level is performed by AMC Czech Republic in accordance with Commission Regulation (EC) No. 2150/2005, Article 5. AMC of the Czech Republic gathers applications of the airspace users for the temporary allocation of restricted areas, where restriction period does not exceed 24 hours and makes decisions on their allocation in accordance with the rules set by the Authority in agreement with the Ministry of Defence and publishes this information via AUP and UUP.

Tactical ASM Level
This level is performed by ATC – ACC Prague units and MIL ACC Prague in accordance with the Commission Regulation (EC) No. 2150/2005, Article 6. In real time they activate and deactivate assigned restricted areas (according to AUP/UUP) or they provide reallocation of areas to users for the purpose of their more effective usage. Activation/deactivation of area (according to AUP/UUP) is provided according to notification of airspace user about real airspace usage.

5.5 Improvement of flow management

The ATM 2000+ Strategy identifies that flow management, together with capacity management is a core operational process of ATM and that it will be an evolutionary step forward in "managing the dynamic balance between capacity and demand".

The report of the Independent Study stated that the current focus was on avoiding the saturation of the control systems and not enough on the optimisation of the efficiency of the global ATC system. It further stated that in its role definition, ATFM should not be restricted to slot allocation mechanisms but should also be extended to the optimisation of traffic patterns and capacity management so that the slot allocation process is achieved in an optimised manner.

In order to achieve this improvement in the management of traffic flows, in which an embedded aim will be the protection of overloads through capacity management, a series of changes (strategic objectives) will be implemented.

Key Drivers for ATFCM Evolution

The evolution of flow management into flow and capacity management is the primary means of ensuring flight punctuality and efficiency, whilst managing at best the available capacity on the air and on the ground. Changes are focused on moving from a flow management system currently based mainly on regulating mechanisms to the essential function of collaborative management of capacity and demand, although it is recognised that this may still entail flow regulation under certain conditions.

The 3 key drivers which will impact on capacity and on the operations of users and the ATM system are:
a) Moving towards a more collaborative approach to capacity management;
b) Improving the adaptability of the ATFM planning strategy;
c) Moving the emphasis towards capacity management.

New subjects

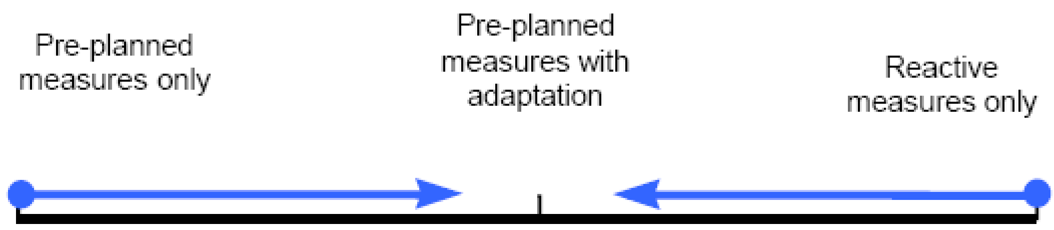
The four trends are further described with a short explanation on their impact on Flow and Capacity Management.

1. Moving towards a more collaborative approach to capacity management

Picture 12: Capacity management

Capacity Management, shown here in picture 12, refers to who performs the management of ATM capacity. The options include the individual resource owners, the local ATS providers or a central Traffic Management Organisation.

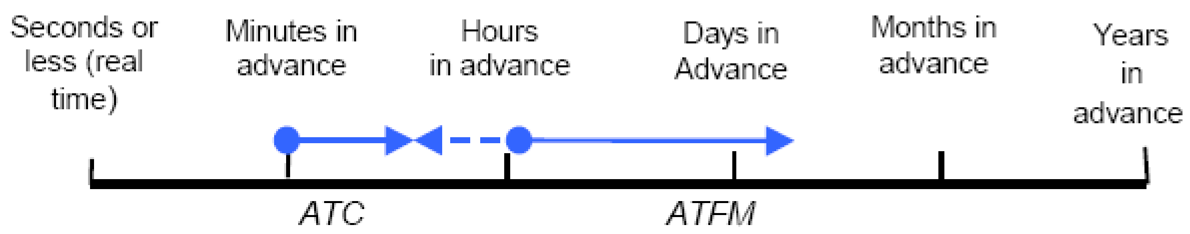
2. Improving the adaptability of the ATFM planning strategy



Picture 13: ATFM Planning strategy

Picture 13: depicts the different planning strategies that may be applied to ATFM. They range from pre-planned measures only, with no subsequent adjustment (i.e. deterministic, early decisions) at one extreme, to purely reactive measures only at the other extreme (i.e. driven entirely by events as they unfold, with no notion of a plan).

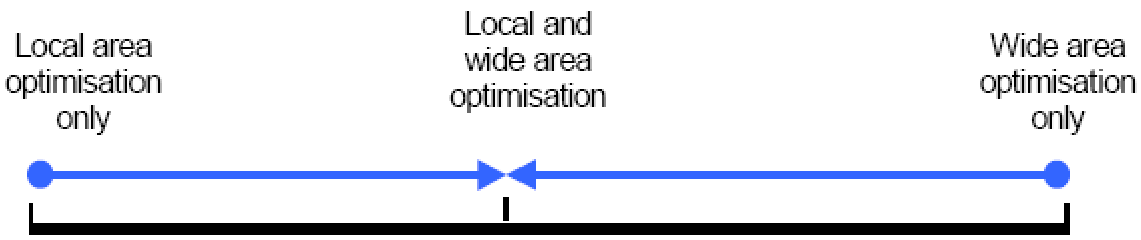
3. Adapting the planning horizon



Picture 14: Planning horizon

Planning Horizon, as used here in Picture 14, refers to when the planning for the sequence optimisation of air traffic is carried out. This may, in theory, be carried out in real-time, minutes in advance, through to years in advance, although not all timeframes will be practical. The trigger for Planning Horizon is the entry time reference location.

4. Expanding Traffic optimisation



Picture 15: Traffic optimisation

Picture 15 refers to the geographic scope of the traffic optimisation activity. This includes the options of a local area optimisation, a wide area optimisation and a combination of local and wide area optimisation. It reinforces the principle of an overarching global view reinforced by local decision making.

Summary

The five key drivers for ATFCM evolution may be summarised as:

- Moving towards a more collaborative approach to capacity management;
- Improving the adaptability of the ATFM Planning Strategy;
- Moving the emphasis towards capacity management;
- Adapting the planning horizon;
- Expanding traffic optimisation.

6. AIRSPACE FLOW AND CAPACITY MANAGEMENT

6.1 History

In 1944, the allied powers signed the Chicago convention which sought to protect international commercial aviation in a manner similar to that already in existence for shipping. Following ratification of the Convention in 1947, the International Civil Aviation Conference was established. The Chicago Convention includes a number of Annexes which define standards and recommended practices for civil aviation.

In essence, the Annexes consider that aircraft operating under Instrument Flight Rules should be separated from those operating under Visual Flight Rules. As this is not always possible or desirable from an operational perspective, ICAO have defined 7 classifications of airspace (A-G – cap. 4) which cater for different mixes of IFR and VFR traffic and prevailing weather conditions.

Unfortunately, the rules are complicated and difficult for a pilot to apply in practice. Moreover, most IFR pilots are unaware of the class of airspace in which they are operating and the changing visual separation responsibilities they have. Another difficulty stems from the fact that the Chicago Convention does not apply to State aircraft although States are required to consider the standards and recommended practices when writing rules for State aircraft operations. Thus civil and military pilots may be operating under very different rules in the same airspace without either pilot aware of the legal responsibilities of the other.

The main role of Air Traffic Services is to prevent collision between aircraft. Only in Classes A-D are all civil aircraft known to ATS and only in Classes A and B are air traffic controllers responsible for the separation of all civil aircraft. In many countries, military aircraft are also under "control" in these airspaces. However, in many countries, and particularly over the high seas, military pilots may be permitted to take visual separation when a civil pilot is expecting IFR separation. This situation is further exacerbated by the fact that there are no defined visual separation minima. Thus in most airspace in ECAC, it is not possible for Air traffic controllers to prevent collisions between aircraft.

Visual separation is assisted by defined limits on visibility and vertical and horizontal distance from cloud. Although defined, it is up to a pilot's subjective decision as to weather he or she is operating under VFR or IFR. Moreover, the visibility minima are appropriate for slow moving aircraft such as a DC3 or C150 with a cruising speed of 140 knots but do not provide sufficient time for avoiding action when speeds are 240 knots or even 480 knots for State aircraft. Thus the airspace design may require pilots to take visual avoiding action but the relative speeds of the aircraft and the prevailing meteorological conditions may make this impossible in practice.

As traffic levels increased, more and more sophisticated air traffic control procedures were required, culminating in the widespread introduction of radar and radar-based separation techniques. However, the rules governing these procedures limit the number of aircraft considerably. To avoid overload situations for controllers, some form of strategic flow management was required. Over time, each State developed its own methods of restricting the flow of traffic in its airspace. Eventually, in 1996, the Central Flow Management Unit was established to provide an ECAC-wide flow management service.

Since 1996, the Central Flow Management Unit has been very effective in facilitating the increase in commercial aviation levels. However, the concept of flow management was independent of airspace design and management and was more focused on individual air traffic control sectors rather than the efficiency of the ATM network.

In shortcut…

ICAO Airspace:

- ✈ Military not (necessarily) included
- ✈ Separate IFR and VFR by airspace design
- ✈ Airspace classified from A to G depending on ATS provided
- ✈ Only in class A and B are all (civil) aircraft separated by ATC procedures
- ✈ Classes C to G require an element of visual separation

Problems:

- ✈ IFR pilots not aware of VFR responsibilities
- ✈ Military rules may be incompatible with civil ATC procedures
- ✈ Difficult for ATC to provide collisions
- ✈ Weather minima good for DC3/C150 but not for B747 or Eurofighter
- ✈ As traffic increases more flow management required

6.2 Current situation

The current situation in ECAC can be seen as a loosely connected series of activities, each of which has been finely tuned to operate as efficiently as possible but without taking into account the requirements and outputs of the other activities. Since an aircraft operator must pass though most or all of these activities, each one can be seen as a hurdle to be overcome on the road to efficient aircraft operation.

Traditionally, ICAO standards and recommended practices have encouraged States to strategically separate State aircraft from civil aircraft and IFR from VFR. Unfortunately, advances in aircraft performance, navigation capabilities and the commercialisation of air transport has meant that this solution is no longer viable, particularly for the core part of Europe.

A more integrated airspace for all aircraft operators following compatible rules and regulations is seen as the best solution. Moreover, a more inclusive and widespread network approach to flow management, using elements of airspace management and the Flexible Use of Airspace Concept bound together by Collaborative Decision Making may enable the ATM system to cope with forecast demand.

Air traffic management:
A series of highly refined disconnected activities all conspiring to prevent the efficient operation of aircraft.

Air traffic control:
A game played by airline pilots and air traffic controllers
The rules of the game are so complicated that neither side knows how it is played, but the goal is to prevent flights from arriving in time for passengers to make connecting flight.

6.3 Airspace strategy overview

To accommodate the operational characteristics of a future system, EUROCONTROL developed the Airspace Strategy for the ECAC States. This considers the whole continuum of airspace and the differing needs of all airspace users on the basis of equity.

In itself, the implementation of the strategy will only bring small benefits in terms of capacity and efficiency. However, implementation of the strategy will enable the introduction of new procedures, techniques and systems which will provide significant gains in capacity and safety.

- ATM 2000+ Strategy – "Gate to Gate"
- Airspace needs to be considered "Gate to Gate"
- Enabling strategy for most operational improvements (ATS, Flow and Capacity management, etc.)

Strategic principles

- Airspace is a finite asset
- Safety is the prime objective
- National security and defence needs have to be satisfied
- Airspace should be managed collaboratively under joint civil/military arrangements
- Strategy have to be evolutionary
- National developments have to be in consultation with neighbouring states
- Changes must be consistent with ICAO ATM/CNS Global Strategy

Strategic objectives

- simplification of airspace organisation
- Airspace management and civil/military co-operation
- Utilisation of user-preferred trajectories
- Route network optimisation

Terminal airspace optimisation
ATC sector design optimisation
Flight planning and information on flight and airspace status

6.4 Airspace organization

The long-term goal of the airspace strategy is to provide 2 airspace environments in which aircraft can operate.

In one, all the aircraft are known to air traffic services; this will enable controllers to prevent collisions between aircraft requesting an avoidance services and plan the efficient use of the network.

In the other airspace environment, not all aircraft will be know to air traffic services. In this airspace, all pilots will have to assume some responsibility for separation although they may be assisted by air traffic services.

These environments will not be considered on the basis of weather minima, speed control, etc, but on the basis of the level of knowledge of air traffic services of the operations taking place.

Picture 16: Airspace where all aircraft are known to the air traffic controllers

Picture 17: Airspace where some or all of the aircraft are not known to the air traffic controllers

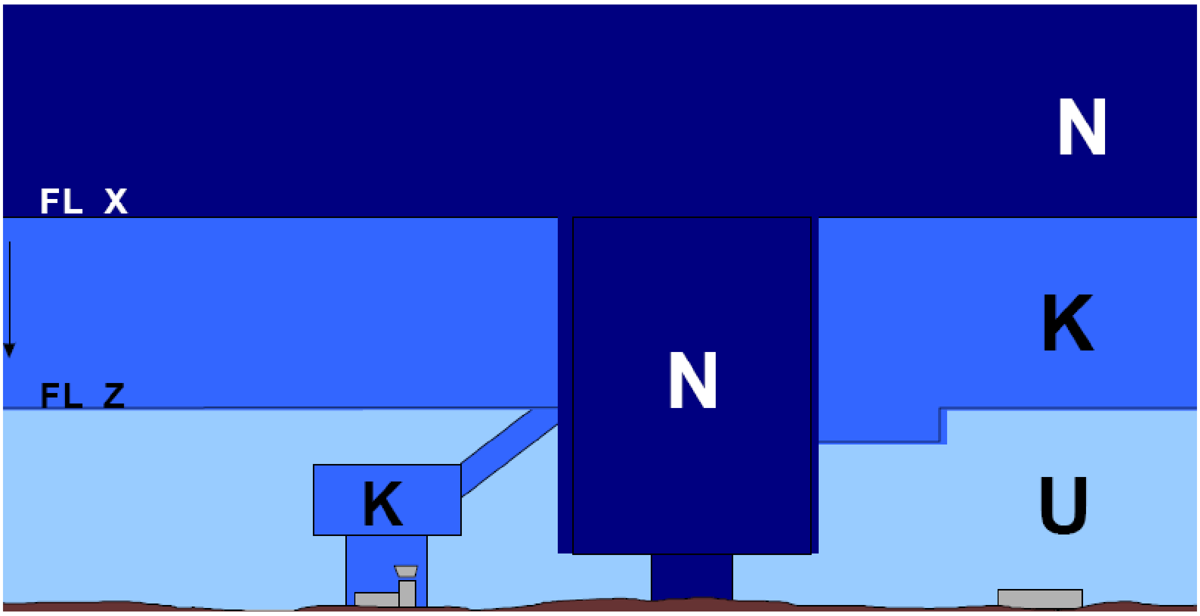
6.5 ECAC Airspace Concept

The next phase of the strategy for airspace organisation is to harmonise and simplify, as far as practical, the application of the ICAO airspace classifications throughout ECAC airspace.
At the same time, the implementation teams are working on the first steps towards the airspace environments. Initially, it is considered that three environments will be necessary as follows:

In traffic environment "**U**", not all traffic is known to air traffic services.
In traffic environment "**K**", all the traffic is known to air traffic services but not all the traffic may be under "control". In this environment, it may not be possible for air traffic controllers to ensure the separation of aircraft using air traffic control procedures alone.
In traffic environment "**N**", all the traffic is known to air traffic services who also have details of flight intentions. This would enable air traffic controllers to provide a full collision avoidance service if required.

U	**U**nknown Traffic Environment (an environment within which not all traffic is known to ATS)
K	**K**nown Traffic Environment (an environment within which all traffic is known to ATS either with position only or with flight intentions as well)
N	I**N**tended Traffic Environment (an environment within which all traffic is known to ATS with both position and flight intentions)

Table 4: ECAC Airspace Concept



Picture 18: ECAC Airspace Concept

The first phase of the implementation of the simplification of airspace organisation has been the harmonisation across ECAC of the ICAO classification of airspace above an agreed division level.

In Oct 2003, all the 7 airspace classes were in use in the upper air. Moreover, some States did not classify their airspace according to ICAO and many more had differences from the standards defined in the ICAO Annexes.

By Jan 2005, the vast majority of ECAC States had implemented ICAO class C above a common level of FL 195.

This has been a major achievement for ECAC and will facilitate enhancements to airspace management procedures and cross-border operations in the future.

6.6 Routes and sectors

Traditionally, the design of the route network has only considered civil aviation requirements. In many countries, State aircraft are provided with segregated airspace for their activities and the route network has to be accommodated around these restrictions. In other countries, State aircraft operate outside the boundaries of the route network but civil aircraft are required to maintain the published routes unless some form of coordination has taken place.

Currently, this design methodology has managed to provide the capacity required. However, it is becoming increasingly difficult to design, strategically, airspace which fully exploits the navigation capabilities of modern commercial aircraft whilst providing increasingly large and flexible volumes of airspace for military activity.

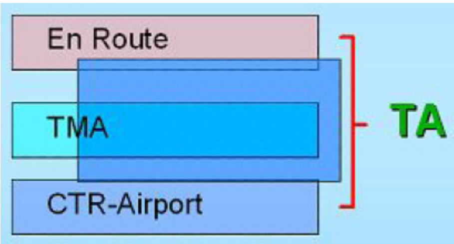
ECAC is unique in the world as the majority of the busiest international airports are all contained within a very small geographical area. This "core area", consisting of about 9% of the ECAC airspace accounts for 65% of all traffic. Moreover, the widespread use of hub and spoke operations by the airline groups means that 50% of all flights operate less than 380 nautical miles.

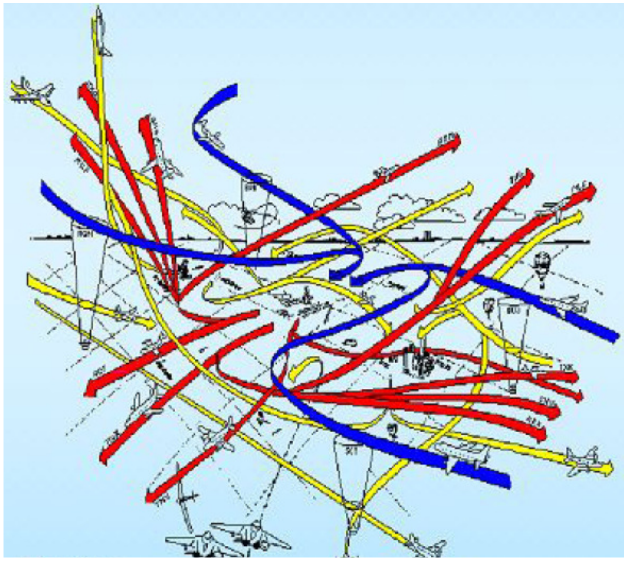
Finally, each State, as an individual signatory to the Chicago Convention, has individual interests, normally from both the civil and military users. Sovereignty issues, as well as political and financial considerations often make it difficult to consider the route network at ECAC level.

6.7 Terminal Airspace

Terminal Airspace (TA) is not a term defined by ICAO. However, the Terminal Airspace Task Force within EUROCONTROL are concerned with the interface between the runways at airports at the en-route network.

Therefore, Terminal Airspace covers the airspace from the upper levels of the airport Control Zone, through the Terminal Manoeuvring Area and into the En-Route structures.





Picture 13: What is this?

Today's TA

Currently, Terminal Airspace can vary considerably. Sometimes, the Control Zone is isolated from the en-route network requiring aircraft to transit airspace without air traffic control. Sometimes, the Zone is embedded into the en-route airspace whilst in others there are link routes or SIDs and STARs connecting the Zone to the en-route system.

One of the main activities in recent years has been the revision of Terminal Airspace to reflect current aircraft performance. There are still instances of SIDs which cannot be flow by modern jet aircraft or which consider climb or speed performances that have not been seen for 30 years.

The modernisation of Terminal Airspace has already done much to improve TMA throughput and relieve some pressures at bust airports. However, airports are now the main cause of delay and further improvements to Terminal Airspace are critical to reducing delay in the future.

7. ATM 2000+ STRATEGY

7.1 Introduction

Purpose

The EUROCONTROL Air Traffic Management (ATM) Strategy for the years 2000+ (ATM 2000+ Strategy) has been developed at the request of the Transport Ministers of the European Civil Aviation Conference (ECAC), to cater for the forecast increase in European Air Traffic which will demand a quantum increase in ATM and airspace capacity. The Strategy describes the processes and measures by which the forecast demand may be satisfied while improving aviation safety. It falls within the framework of the ICAO regional and global CNS/ATM planning, the ECAC Institutional Strategy and the revised EUROCONTROL Convention.

History

At the fifth meeting of ECAC Transport Ministers (MATSE/5) in Copenhagen on 14th February 1997, Ministers adopted an Institutional Strategy for Air Traffic Management (ATM) in Europe and decided that the revised Convention, which was signed later in 1997, would be the legal instrument for the implementation of the ECAC ATM Institutional Strategy.
In addition, the Ministers requested a proposal for a comprehensive, 'gate-to-gate' orientated ATM Strategy for the years 2000+ as a follow-up to the En-Route and Airport Strategies for the 1990s. The ATM 2000+ Strategy follows on from the ECAC Strategies for the 1990's. The Strategy Proposal was developed by a Board composed of senior managers from all sectors of aviation and reviewed by the EUROCONTROL Provisional Council. On 23 April 1999, the EUROCONTROL Permanent Commission took Decision No. 79 approving the ATM Strategy for 2000+, as endorsed by the Provisional Council, and agreed that it should be presented to ECAC Ministers of Transport. The Strategy was adopted by the Ministers at their MATSE/6 meeting on 28 January 2000. The Ministers directed EUROCONTROL to put in place, as a matter of urgency, an Action Plan to implement the Strategy, and to keep it under review in the light of changing circumstances and develop consequent alternatives.

Past and current problems

The ECAC En-route and Airport Strategies for the 1990s led to the introduction of the European Air Traffic Control Harmonisation and Integration Programme (EATCHIP) and Airport/Air Traffic System Interface (APATSI). These, together with the implementation of the Central Flow Management Unit (CFMU), have helped to provide a steady improvement in ATM capacity and efficiency. In addition, following the completion of EATCHIP and APATSI in 1998, a number of measures were implemented by the ECAC States within the framework of the European ATM Programme (EATMP) or directly at national level, thereby allowing the enhancement of the European ATM system to continue. However, the capacity of the ATM system continues to lag behind the demand in a number of States, and the pressures on the ATM system are increasing.

The improvements realised thus far to the ATM network have been largely overtaken by the increase in the number of flights and, while there has been a fall in flight numbers following the terrorist attack in 2001, air traffic levels are expected to recover and then continue to rise again in the foreseeable future. The traffic increase and other factors imply that further substantial gains have to be found in safety levels in the whole of Europe, and in ATM capacity in much of the European airspace that already experience capacity shortfalls, or which is likely to do so in the future.

Whilst the delay issue has been widely discussed, it should be remembered that the primary purpose of ATM is safety, and it is for safety reasons that capacity is limited to prevent overloading of the ATM system. Any attempt to accommodate higher levels of traffic will have to be accompanied by even more stringent safety requirements. This, however, should not mask the need to identify safety issues in the current system, and to devise measures to remedy them. This task is made more difficult due to the current lack of and difficulty in collecting, comprehensive and consistent safety data to identify safety issues. ATM improvement measures also have the potential to reduce the wider aviation risks.

Air traffic planning and management processes needs to be strengthened to ensure that the ATM system is able to provide timely responses to the expanding calls on its services. Also that these are based on sustainable investment plans and system upgrade paths. Additionally, air traffic processes have to become more efficient and dynamic if they are to meet the Airspace Users requirements for more cost-effective and flexible operations that are responsive to their business needs .

While the tragic events of 11 September 2001 have had a profound impact on passenger confidence and the aviation industry in general, the main effects are mostly likely to be concentrated in the shorter-term. The fall in air passenger numbers and slow down in traffic growth provides an opportunity for ATM to close the present gap between the capabilities and demands made on the ATM network, but does not obviate the need for the changes that are necessary to meet the challenges that ATM will face over the life time of the Strategy.

These changes require the progressive introduction of new operational and technical solutions based on an overall top-down and performance-driven system approach that will support sustained aviation growth and meet both the Airspace Users business needs and the travelling public's expectations for safe, reliable, punctual services that offer value for money.

These changes call for a European ATM strategy, based on a consensus within the aviation community on a common goal and evolution path.

Limitations of the present system

The current ATM concepts and systems have a number of shortcomings. Particular limitations are:

- ✈ disparate services and procedures resulting from differing systems, and limited system-support for tools for the controller;

- a reliance on increasingly congested voice radio communications for air-ground exchanges;
- rigid airspace divisions and route structures which are often predicated on national needs, and which do not utilise the totality of European ATM resources to the best effect;
- a lack of collaborative planning and limited facilities for real-time information exchange between ATM, airport operating authorities and Airspace Users, as well as between civil and military, resulting in inflexible responses to real-time events and changes to users' operational requirements and less than optimum use of scarce airport air-side capacity;
- the inability to fully exploit the potential for efficiency and capacity gains offered by aircraft avionics capabilities;
- a severe shortage of controlling staff in a number of States stemming from national financial constraints and the absence of validated planning data at the European ATM network level;
- the long lead-times involved in developing and deploying improved systems in aircraft fleets or in the ground infrastructure which, in turn, result in complex transition planning and high costs. This is exacerbated by the delays encountered in many ATM projects.

One of the major operational problems is the current means of airspace sector operations and resultant Air Traffic Control (ATC) workload. An essential component of that workload is the volume of routine air-ground radio communications messages, which in peak traffic conditions can approach saturation point.

Traditionally, capacity gains have been obtained by dividing airspace into smaller and smaller control sectors to offset the increases in workload generated by additional flights, and this will remain the primary means to increase capacity in the shorter-term. However, this technique follows a law of diminishing returns, as it generates additional co-ordination workload and reduces the ability of sectors to handle traffic situations independently. It is reaching its useful limit in some of the busier airspace areas and other, additional, means have to be found to enhance capacity in the medium to longer-term. While advances in technology will provide a platform for future safety, capacity and efficiency gains and cost savings, they have to be accompanied by operational, organisational and institutional changes before these benefits can be realised. The best practical path is therefore to introduce new concepts and procedures, supported by technical improvements and improved management and regulatory processes to create a safer environment and thus provide the types and standards of ATM services that the Airspace Users require.

Main features

Delivering safety and performance

PERFORMANCE ORIENTED AND SAFETY COMES FIRST	✈ Notion of ATM performance, as the set of criteria expressing the expectations of society and airspace users. ✈ Performance includes safety as its first element, all other criteria are always subordinated to it.

PROMOTION OF OVERALL SAFETY IMPROVEMENT AND MEASUREMENT	✈ Beyond the necessary introduction of safety management and safety regulatory functions in ATM ✈ To anticipate, identify and remedy safety problems in aviation where ATM has the potential to contribute safety improvements.
A STRUCTURAL REVISION OF ATM PROCESSES A NEW ATM CONCEPT A SYSTEMS APPROACH FOR THE ATM NETWORK	Best use of airspace can only be achieved if the traditional Air Traffic Control (ATC) concept is replaced, in a controlled way, by a new ATM concept. A Systems Approach is needed, recognising the interdependence of stakeholders' operational decisions, encompassing the gate-to-gate concept, the consistent management of all phases of flight, the application of uniform principles, the integration of airport airside5 operations into ATM and system-wide information sharing, thus the notion of ATM network. Organisational means will be introduced to manage the complexity of the traffic situation and to manage the ATM network as an integrated whole via seamless services.
ONE AIRSPACE CONTINUUM, GATE-TO-GATE	✈ For ATM purposes, gate-to-gate, not constrained by national or service provision boundaries. ✈ In conjunction with other measures, this should significantly improve the effective use of airspace and airports and provide the maximum freedom of movement for all airspace users, together with positive cost-benefit results and environmental benefits.
FULL CIVIL-MILITARY CO-OPERATION	Emphasis on the need for further improvements in civil-military co-ordination and co-operation to fully exploit the airspace continuum.

Overall objective

The overall objective of the European ATM network is:

For all phases of flight, to enable the safe, economic, expeditious and orderly flow of traffic through the provision of ATM services which are adaptable and scaleable to the requirements of all users and areas of European airspace. The services shall meet demand in a cost-effective way, be globally inter-operable, operate to uniform principles, be environmentally sustainable and satisfy national security requirements.

7.2 The major strategic objectives

General
To achieve the Overall Objective and vision, certain principles shall be systematically applied throughout the European ATM network during the life-cycle of all ATM projects. It is also essential to define clear strategic performance objectives for the ATM network. However, the airspace users have not all the same expectations; for example military are less interested in the throughput/delay aspect of capacity than in that of access to airspace volumes and need a cost-effective solution in terms of productivity, flight efficiency and mission effectiveness. In addition, traffic levels in European airspace vary from region to region and over time, creating different performance requirements. Performance indicators should be meaningful to all airspace users, as well as to service providers and regulators.

Principles: All airspace users shall receive services of a nature and quality that satisfy their requirements and for which they are willing to pay. Performance targets shall be defined and monitored.

There are 9 objectives:

- Safety
- ATM Security
- Cost-Effectiveness
- Capacity
- National Security and Defence Requirements
- Environment
- Human Involvement and Commitment
- Uniformity
- Quality

Now I would like to talk above all about two of them.

7.2.1 Safety

Enhancing safety levels has an effect both on the ability to accommodate increased traffic demand and on operational efficiency since intervention of ATC is aimed at ensuring safe separation between aircraft. If the increase in the number of flights is to be accommodated, the establishment of appropriately safe conditions shall precede the achievement of more capacity. In addition, the maintenance of, or improvements to, existing safety levels will require a new, top-down and rigorous systems approach to safety involving harmonised safety policies and actions for both safety management and a strong safety regulation, with emphasis placed on continuous Safety Improvement and Measurement. This may include the introduction of a number of operational improvements dedicated to safety.

Principles: Safety is of the highest priority in aviation, and ATM plays an important part in ensuring overall aviation safety. Uniform safety standards and safety risk management practices shall be applied systematically to the European ATM network. Within the total aviation safety system approach, an ATM safety regulatory regime shall be established, the functions of which shall be separated from service provision at both European and national level. ATM safety objectives shall be established. Safety performance shall be monitored and improved.

Objective: To improve safety levels by ensuring that the numbers of ATM induced accidents and serious or risk bearing incidents do not increase and, where possible, decrease.

The main purpose of ATM services is to ensure the safe separation of aircraft, both in the air and on the ground, while maintaining the most efficient operational and economic conditions. The formulation of the objective implies a reduction of the accident rate per operation or flight hour substantially greater than the rate of increase in traffic. In addition, key risk areas in aviation where ATM can contribute remedial measures should be identified and the subject of action.

7.2.2 Capacity

Principles:

ONE AIRSPACE CONTINUUM

The European airspace shall, for ATM purposes, be considered a continuum and shall not be constrained by national or service provision boundaries. Regional developments based on similar national requirements shall be encouraged.
The planning, operational division, management and use of the airspace shall reflect this principle and be done in a coherent way. The financial arrangements among service providers should reflect the operational organisation.

FREEDOM OF MOVEMENT

All airspace users shall have maximum operational freedom within the scope of the other principles and in accordance with international laws.

Objective: To provide sufficient capacity to accommodate the demand of all users in an effective and efficient manner at all times, and during typical busy hour periods without imposing significant operational, economic or environmental penalties under normal circumstances. To enable airports to make the best use of potential capacity, as determined by the infrastructure in place (land-side and air-side), political and environmental restrictions, and the economical use of resources.

Capacity is a complex mix of access to airports, airspace and services, predictability of schedules, flexibility of operations, flight or mission efficiency, delay, timely availability of volumes of airspace, and network effects. ATM and airspace capacity-related aspects also include controller workload, weather conditions, availability of communications, navigation and surveillance systems, and other factors (e.g. radio frequency spectrum). The most visible symptom of capacity shortfall is the level of delays.
A major obstacle to producing more en-route capacity is that, despite efforts like the introduction of the FUA concept, effective use of European airspace has not been achieved. While some States have concluded cross-border airspace agreements, the present organisation and management of airspace must be improved, used more flexibly and not constrained by boundaries. By removing the ATM constraints linked to boundaries, airspace capacity can be managed most

effectively. The access to airspace by different types of airspace users also calls for more responsive airspace management processes to best match the needs of all users.

7.3 Directions for change

7.3.1 Airspace organisation and management

The main actions will be to simplify the airspace organisation, improve airspace management and civil-military co-ordination, optimise the route network, ATC sector design and terminal airspace organisation, allow maximum use of user-preferred trajectories and optimise the airspace procedures. Airspace design (flight information regions, centres, sectors, routes) will be prepared with the participation of all stakeholders under the auspices of EUROCONTROL.
Airspace management will move to a regime whereby airspace boundaries are adjusted dynamically to particular traffic flows and peaks in demand, thanks to collaborative European airspace management. Flexible route and airspace structures will be implemented where possible and traffic organised when necessary. This will provide the most efficient and cost-effective solutions with regard to safety, capacity, productivity, flight efficiency and mission effectiveness for the benefit of Europe as a whole, while lessening the environmental impacts, and taking into account the needs of all airspace users, civil and military. Advances in avionics, the development of Area Navigation (RNAV) techniques, advanced ATC decision supporting tools and improved navigation systems, will be the main enablers.

7.3.2 Flow and capacity management

Flow and Capacity Management is necessary from strategic planning to tactical execution of flights to optimise the use of available ATC capacity. Improvements will be based on a gradual shift from managing the demand to collaboratively and pro-actively managing the capacity of the ATM network, through increased overall responsiveness by real-time and optimised tactical procedures, and pro-active and informed collaborative decisions on alternatives.

Flow and Capacity Management will remain a preventive mechanism, primarily for:

- Tactical management of arrival and departure flows – since airport capacity will be a major limiting factor in the ATM network.
- Residual en-route problems, peak periods and exceptional circumstances.
- Management of traffic densities to support enhanced flexibility in airspace use.

Enhanced Central Flow Management Unit (CFMU) services, improved ATFM techniques and tools based on the capture and integration of current traffic, airspace management and capacity data will help to further enhance safety and the utilisation of capacity through the avoidance of potential ATC overloads.

7.3.3 En-Route and terminal ATC

Safety-net tools assist in reducing the risk of aircraft collisions and will be used to monitor the traffic situation and trigger alarms when safety parameters are likely to be infringed. In addition to the strategic organisation of traffic and the further automation of routine tasks, productivity will be increased through:

- Use of automated tools to assist the controller in planning and tactical decision-making and communications in all phases of flight.
- Redistribution of control tasks within sector teams or between controllers within a control centre, using the flexibility provided by data communications.
- Co-operative air traffic services based, initially, on greater situational awareness and controller pilot data communications, and then delegation of separation tasks to the flight crew in well defined and duly regulated circumstances. Agreed 4D trajectory contracts between the air and the ground will also enhance their co-operation.

The procedures, capacity gains, costs and other requirements associated with the delegation of separation tasks will be evaluated, and safety and human factors analyses undertaken, both to verify the feasibility of such operations and to define their conditions of applicability. These changes depend on the provision of accurate real-time data on aircraft position and intent, and improvements in flight data processing systems and in CNS systems, in particular mobile data communications, increased surveillance efficiency, and navigation system performance. These improvements and the related data semantics and quality requirements call for extended criteria and new forms of interoperability.

7.3.4 Airport ATC

Improvements will be brought to the management of arriving and departing aircraft, and of aircraft on the movement area, as well as to runway capacity and utilisation, and airport operations efficiency in all weather conditions within the limits imposed by political/environmental restrictions. They will be accompanied by, and integrated with, better management of the land-side infrastructure as the airport is a key stone in the realisation of a gate-to-gate network. Operational and strategic co-ordination between aircraft operators, airports and ATM, based on CDM applications, will allow to resolve conflicting goals.

The Airport operational environmental protection will address procedures for minimising the impact of aircraft noise and of gaseous emissions, the application of, and compliance with, pan-European harmonised environmental standards and regulations, and the management of noise capacity. ATM operational initiatives at airports and efficient use of the available movement areas and associated infrastructure will bring capacity, efficiency and environmental gains in terms of reduced airborne delay and ground waiting times, and also enhance the safety of aircraft and other traffic on the airport manoeuvring area. Changes to procedures will be enabled by runway management tools, arrival/departure management systems, and advanced surface movement guidance and control systems. These measures will allow to optimise the use of available infrastructure, but are not a substitute to the ultimate need for more runways.

8. INDICATORS OF AIR TRAFFIC DANGEROUSNESS

8.1 Phases of the flight

It is obvious, that safety is one of the most important topics in general when we are talking about flying. And it is also bears with other important problems.
One of them is capacity.

SAFETY	**EFFICIENCY**
PERMEABILITY	**CAPACITY**

Capacity is one of the main factors which affects the safety. Now I will try to describe all flight phases to look to this problematic in more detail.

8.1.1 Taxi

Definition: the aircraft is moving on the aerodrome surface under its own power prior to takeoff or after landing. This phase of flight includes the following sub-phases:

- *Taxi to Runway:* Commences when the aircraft begins to move under its own power leaving the gate, ramp, apron, or parking area, and terminates upon reaching the runway.
- *Taxi to Takeoff Position:* From entering the runway until reaching the takeoff position.
- *Taxi from Runway:* Begins upon exiting the landing runway and terminates upon arrival at the gate, ramp, apron, or parking area, when the aircraft ceases to move under its own power.

Each normal standard flight consists of several phases. Two general phases are movements on the *ground* and in the *air*.
The ground phases occur every time in the beginning of the air phase and also in the end of it. Before the airplane goes to the air it has to taxi to the RWY. This phase seems to be too far to be affected by capacity, but that is not completely truth. The air traffic growth logically means more airplanes - more airplanes not only in the air but also on the ground. The moving speed of airplanes is of course much slower than in the air, but on the other hand the airspace is much larger, than the airport area.

It holda generally, that whereby airplanes are moving slower, thereby the spacing among them can be smaller. That holds naturally contrariwise too. But this also means that by moving on the ground the level of dangerousness does not blaze down.

Farther, taxiing to the active runway and the resulting take off is basically the first process, in which first spacing management steps to prevent further problems can be implemented.

The present situation is that not only the biggest and most important airports or hubs have limited capacity. Due to this fact it is obvious, that also safety problems are increasing. To ensure stabile or decreasing level of safety during increasing capacity, some steps must be done.

Picture 14: Airbus A380 ready for take off

To prevent collisions and mishaps, several systems and procedures are used. Just for example, on bigger airports with heavy traffic ground radars are established (airport radars if you like) which monitor situation on taxiways and runways and in case of emergency inform air traffic controller (ground division) that it is necessary to take some steps to prevent this situation.
Another solution is SID (Standard Instrument Departure) let us say STAR (Standard Instrument Arrival).
In ANNEX E it is possible to find SID and STAR for Prague airport, just for your imagination. Those SIDs and STARs are more wedded with following phase of flight.

8.1.2 Take-off and initial climb

Definition: from the application of takeoff power, through rotation and to an altitude of 35feet above runway elevation. This phase of flight includes the following sub-phases:

- *Takeoff:* from the application of takeoff power, through rotation and to an altitude of 35feet above runway elevation or until gear-up selection, whichever comes first.

- ✈ *Rejected Takeoff:* during Takeoff, from the point where the decision to abort has been taken until the aircraft begins to taxi from the runway

For fluent air flow for each airport SIDs and STARs are set. Those routes contain above all the criteria for apprehension hights above obstacles and requirements for apprehension spacing among airplanes. The SID starts in the point, where the airplane reaches 16ft (5m) after the take off. For this moment the DER considers (Departure End of the Runway). It ends over defined radionavigation apparates or over the report point which are already suited on the airway or on the RNAV way. In case of building the departure tracks, following aspects are respected:

- ✈ *Significant obstacles* – the tracks are built to be affected by obstacles in a minimum way. One of the ways of managing that is to project the turn after take off;
- ✈ *ATC requirements for spacing indemnity* – Safety spacing among the airplanes can be possible by setting more departure tracks;
- ✈ *noise limitation requirements* – It is necessary to protect near living people from the air traffic noise as much as possible. That's why the tracks must be projected also according to those limitations;
- ✈ *placing of radionavigation systems* – The tracks must be in the vicinity (in working area) of radionavigation settlement. Except RNAV track on which airplanes do not need those systems.

The construction of the tracks take into account, that all engines of the airplane are working and the airplane is able to climb with gradient of 3,3% which is called PDG (Procedure Design Gradient). In fact, we distinguish two types of standard departure tracks:

- the direct departure and
- departure with the turn

Direct departure means that initial phase of departure doesn't diffracts more that fifteen degrees from the runway axis.
Departure with the turn is carries out when it is not possible to proceed straight. The reasons are mainly to avoid the obstacle due to ATC routes. But there is also a straight flight – to the high of 395ft (120m).

It is generally known that take off and landing are the most dangerous phases of the flight. The airplane is moving quite slow and in small altitudes. And out of those two landing and final approach are most dangerous at all. About that phases I will mention later.

8.1.3 Climb

Definition: from the end of the Takeoff sub-phase to the first prescribed power reduction, or until reaching 1000feet above runway elevation or the VFR pattern, whichever comes first

- ✈ *Climb to Cruise:* from completion of Initial Climb to arrival at initial assigned cruise altitude.

This phase is directly tied together with take off. In this phase, the airplane is flying on its maximum throttle because it is trying to achieve the best flight level, in which the fuel consumption is optimal and also passenger comfort is the best.
This phase is quite safe as far as we talk about airplane systems. But the safety which is wedded by capacity and collisions is not so clear. Every time the airplane is changing its position (in vertical or horizontal way) the possibility of a mishap grows.

8.1.4 Cruise (En-route)

Definition: from completion of Initial Climb through cruise altitude and completion of controlled descent to the Initial Approach Fix (IAF). This phase of flight includes the following sub-phases:

- *Cruise:* Any level flight segment after arrival at initial cruise altitude until the start of descent to the destination.
- *Change of Cruise Level:* Any climb or descent during cruise after the initial climb to cruise, but before descent to the destination.

I think, in this regime, the capacity safety is one of the highest. Because the airplane is flying straight and it is changing neither altitude or course. Of course there are also situations which can be potential dangerous. For example when an unpredicted situation happens (this can happen of course in all other phases). It can be lots of various things (hijack, technical problems, injury or illness on board, bad weather conditions, etc.) but in almost all cases they may cause trouble.
The pilot, as well as air traffic controller must react to these situations and make place for this airplane in trouble. But this is very difficult and dangerous almost every time (especially in places with heavy traffic). The airplanes are moving very fast and also the distance between them is not so big.
The pressure on air traffic controllers and also on the crew and passengers is very big in these situations.

Picture 15: Airbus A380 cruising

8.1.5 Descend

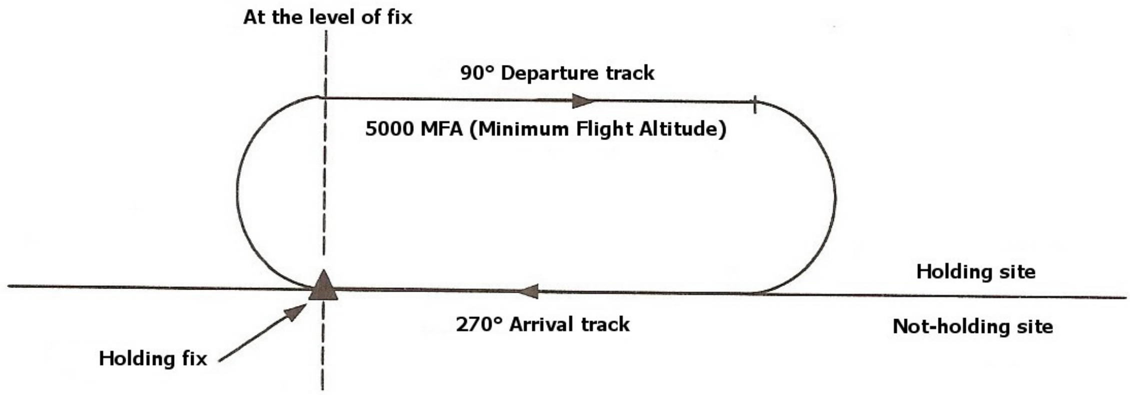
Definition: descent from cruise to either Initial Approach Fix (IAF) or pattern entry.

This is in fact opposite situation to climbing. Because of growing concentration of the traffic, it is impossible to vector all airplanes from tracks and flight levels to one airport at the same time. To solve this problem, holding points and patterns were set up.

8.1.6 Holding

Definition: execution of a predetermined manoeuvre (usually an oval race track pattern) which keeps the aircraft within a specified airspace while awaiting further clearance. Descent during holding is also covered in this sub-phase.

Holding is the process of which the goal is to hold back the airplanes in order to sequence to approach to observance required spacing. The airplane is maintaining its speed and altitude during holding manoeuvre and it is moving in holding pattern.



Picture 16: Scheme of the holding pattern

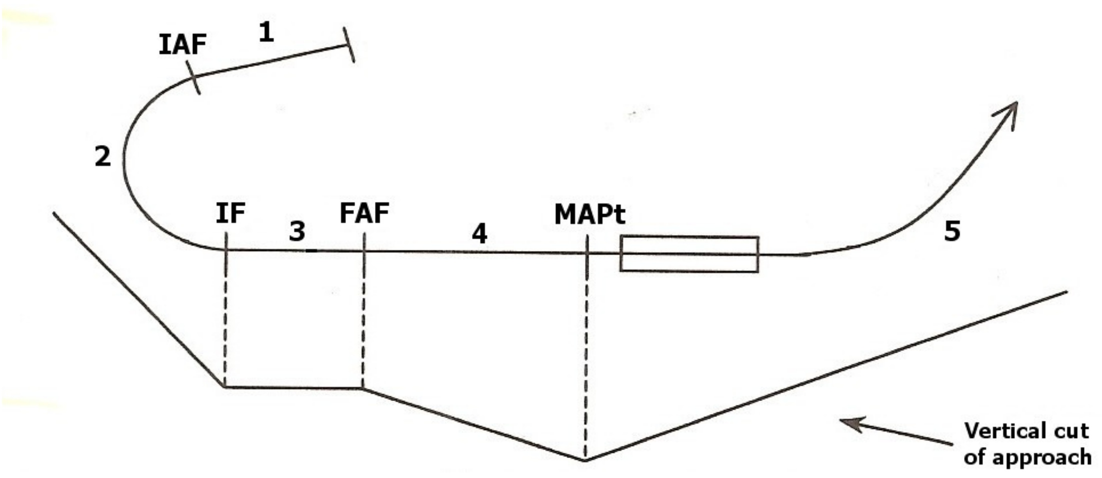
There can hold more airplanes in one holding pattern but in different altitudes. In this situation, the airplane which is in the lowest position leaves the holding pattern first. The rest of the airplanes are descending to lower levels of the pattern.

8.1.7 Approach

Definition: from the Initial Approach Fix (IAF) to the beginning of the landing flare. This phase of flight includes the following sub-phases:

- Initial Approach: From the IAF to the Final Approach Fix (FAF).
- Final Approach: From the FAF to the beginning of the landing flare.

The approach according IFR is the final phase of the flight. The airplane is guided according to STAR to make landing. The approach consists of 5 sections which you can see in the picture on a next page.



Picture 17: Scheme of approach phases

1 – arrival track	IAF – Initial Approach Fix
2 – initial approach segment	IF – Intermediate Fix
3 – intermediate approach segment	FAF – Final Approach Fix
4 – final approach segment	MAPt – Missed Approach Point
5 – missed approach segment	

It looks like this is the opposite situation to the initial climbing after take off. This is of course the truth, except for climbing, the situation is going to be simpler. It means the airplane is retracting landing gear, flaps, etc. While with descending the situation is more difficult. This is one of the reasons why this phase of flight is one of the most dangerous. The airplane is in relative small altitudes and in a small speed. The pilot and co-pilot are very busy preparing systems to landing so they can be unconcentrated for doing other things – for example to the communication with a controller. So if something happen in this phase of flight it is always very dangerous.

8.1.8 Landing

Definition: from the beginning of the landing flare until aircraft exits the landing runway, comes to a stop on the runway, or when power is applied for takeoff in the case of a touch-and-go landing

This phase of flight includes the following sub-phases:

- Flare: Transition from nose-low to nose-up attitude just before landing until touchdown.
- Landing Roll: After touchdown until aircraft exits the landing runway or comes to a stop, whichever occurs first.

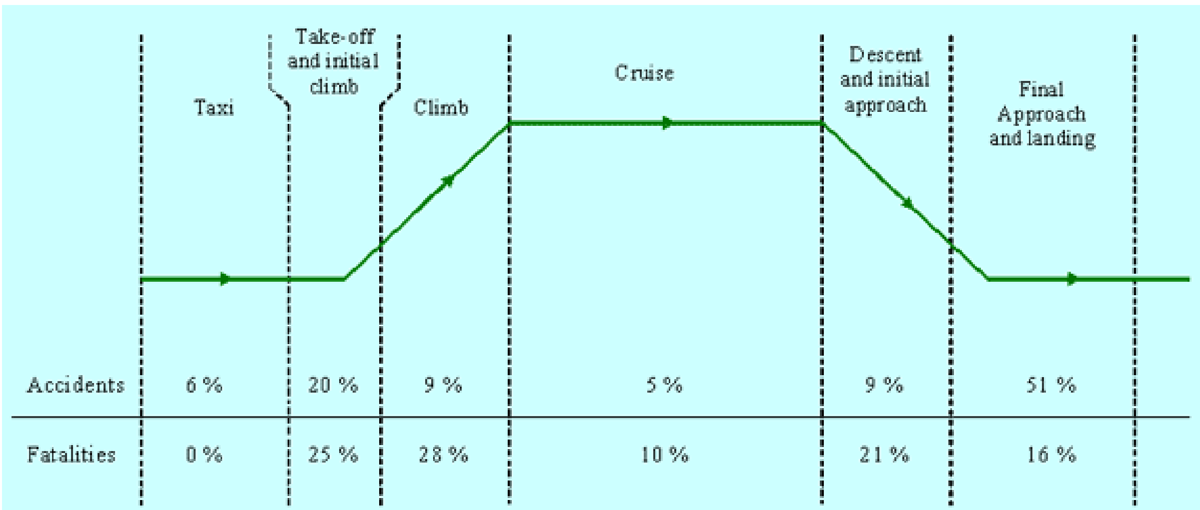
Landing is the very last phase of a flight. When pilot a makes landing manoeuvre there are just two possibilities what he can do. The first one is of course to finish landing and land. The second one is to make a miss-approach and to try to repeat the pattern and land again.

Also during these situations the risk of mishap or collision is very big. But in these phases it is mostly a collision with the ground, not with other airplanes. The capacity is also problem here (due to small distances among airplanes), so controllers have to check this situation very carefully and have to be ready for immediate reaction, in case of an abnormality.

Picture 18: Boeing A380 is doing landing manoeuvre

8.1.9 When does the accident occur?

In this picture below, you can see the percentage of accidents and fatalities which happen in each flight phases.



Picture 19: Statistics observed on the 1995-2004 period

The second study conducted by NLR (A review of civil aviation accidents – ATM related accidents 1980-2001) reviewed civil aviation accidents based on a selection of accidents of following types: wake vortex induced accidents, accidents involving

two or more aircraft, accidents involving one aircraft and one or more ground vehicles and accidents involving problems with landing aids. The accidents taken into account occurred during the period 1980-2001 and involved fixed wing aircraft with MTOW greater than 5.7 tonnes operated in public transport, business, commercial training and ferry/positioning flights.
This study highlights the relative importance of accidents occurring during taxi phase among all collisions. Accidents during taxi phase in Western Europe and North America represent three quarters of the 213 accidents. The accident rate for this phase of flight is therefore relatively high (0·297) compared to the other phases accident rate.
Being more numerous, those accidents (taxi accidents) are less fatal. The fatal accident rate for collision with vehicle and standing aircraft on the ground is reduced against the fatal accident rate for collision with another aircraft, both being airborne.

Phase of flight and region	Western Europe	North America	Total accidents world-wide	Accident rate by phase of flight
Taxi	29	91	144	0.297
Missed approach / go-around	1	0	1	0.002
En route	4	12	24	0.050
Take off	3	5	13	0.027
Landing	3	8	14	0.029
Approach	1	8	17	0.035
Total accidents	42	124	213	0.440
Accident rate by region	0.440	0.440	0.440	

Table 5: Distribution of accidents and accident rate (per million flights) by phase of flight

Between the time a passenger boards the airplane and the time when this passenger has disembarked, there are several different phases which I tried to describe before, but just for better overview…

- *Taxi:* the aircraft taxis on the airport to reach the runway (or it taxis to the gate after landing).
- *Take off and initial climb:* the aircraft accelerate, lift off and start climbing.
- *Climb:* slats/flaps are retracted, and the aircraft climb until its cruise altitude.
- *Cruise:* the aircraft flight at an almost constant altitude (this is generally the longest phase of the flight).
- *Descent and initial approach:* the aircraft descents to get closer to the destination airport. The air traffic control may request loiter, so that the aircraft can wait his turn for the next phase.
- *Final approach and landing:* the aircraft, set in landing configuration and aligned with the runway axis, approaches the runway threshold, then it lands and brake.

Summary
More than half of the accidents occurs during final approach and landing. But they are not the most dangerous for passengers (for example, a runway overrun may result in only a few injuries).
Fatal accidents are more likely to occur during climb. If the aircraft left the gate with undetected failures or defaults, it may be revealed during climb (first long phase off the ground), and could become a danger. If the crew believes the failure necessitates to land as soon as possible, he will decide to perform an IFTB (In-Flight Turn Back). But it could turn out to be difficult because the aircraft has lost some capabilities.
Most of the accidents and fatalities are associated with departure (take off / climb) and arrival (approach/ landing) phases. During these phases aircraft are close to the ground and in a more vulnerable configuration than in other phases of flight: the crew deals with a high workload and reduced maneuver margins.

Definition of air traffic incidents
"Air traffic incident" is used to mean a serious occurence related to the provision of air traffic services, such as:

a) aircraft proximity (AIRPROX)
b) serious difficulty resulting in a hazard to aircraft caused, for example, by:
    1) faulty procedures
    2) non−compliance with procedures, or
    3) failure of ground facilities

Definitions for aircraft proximity and AIRPROX.
Aircraft proximity: a situation in which , in the opinion of the pilot or the air traffic services personnel, the distance between aircraft , as well as their relative positions and speed, has been such that the safety of the aircraft involved may have been compromised. Aircraft proximity is classified as follows:

Risk of collision: the risk classification of aircraft proximity in which serious risk of collision has existed.
Safety not assured: the risk classification of aircraft proximity in which the safety of the aircraft may have been compromised.
No risk of collision: the risk classification of aircraft proximity in which no risk of collision has existed.
Risk not determined: the risk classification of aircraft proximity in which insufficient information was available to determine the risk involved, or inconclusive or conflicting evidence precluded such determination.
AIRPROX: the code word used in an air traffic incident report to designate aircraft proximity.

8.2 Separation

As I said a few times before, the capacity is closely connected with safety. The relation between them is following: when the capacity is increasing – the safety is getting worse and contrariwise.

When we look above our heads it seems a tall story, that sky has an unlimited capacity. But it has. In fact, the problem of insufficient capacity is already here. Not really in the Czech airspace but over significant points, on tracks with heavy traffic and in the vicinity of huge airports, this problem already exists.
I would like to focus now on the limitations, which determine airspace capacity.

Vertical or horizontal separation shall be provided:

a) between all flights in Class A and B airspaces;
b) between IFR flights in Class C, D and E airspaces;
c) between IFR flights and VFR flights in Class C airspace;
d) between IFR flights and special VFR flights; and
e) between special VFR flights, when so prescribed by the appropriate ATS authority;

except, for the cases under b) above in airspace Classes D and E, during the hours of daylight when flights have been cleared to climb or descend subject to maintaining own separation and remaining in visual meteorological conditions.

No clearance shall be given to execute any manoeuvre that would reduce the spacing between two aircraft to less than the separation minimum applicable in the circumstances.

Larger separations than the specified minima should be applied whenever wake turbulence or exceptional circumstances such as unlawful interference call for extra precautions. This should be done with due regard to all relevant factors so as to avoid impeding the flow of air traffic by the application of excessive separations.

Where the type of separation or minimum used to separate two aircraft cannot be maintained, action shall be taken to ensure that another type of separation or another minimum exists or is established prior to the time when the previously used separation would be insufficient.

8.2.1 Vertical separation

Vertical separation application

Vertical separation is obtained by requiring aircraft using prescribed altimeter setting procedures to operate at different levels expressed in terms of flight levels or altitudes.

Vertical separation minimum

The vertical separation minimum (VSM) shall be:

a) within designated airspace, subject to regional air navigation agreement: a nominal 300 m (1 000 ft) below FL 410 or a higher level where so prescribed for use under specified conditions, and a nominal 600 m (2 000 ft) at or above this level; and

b) within other airspace: a nominal 300 m (1 000 ft) below FL 290 and a nominal 600 m (2 000 ft) at or above this level.

Minimum cruising level

Except when specifically authorized by the appropriate authority, cruising levels below the minimum flight altitudes established by the State shall not be assigned.

Area control centres shall, when circumstances warrant it, determine the lowest usable flight level or levels for the whole or parts of the control area for which they are responsible, and use it when assigning flight levels and pass it to pilots on request.

Assignment of cruising levels
Except when traffic conditions and co-ordination procedures permit authorization of cruise climb, an area control centre shall normally authorize only one cruising level for an aircraft beyond its control area, i.e. that cruising level at which the aircraft will enter the next control area whether contiguous or not. Aircraft will be advised to request en route any subsequent cruising level changes desired.
Aircraft authorized to employ cruise climb techniques shall be cleared to operate between two levels or above a level.

If it is necessary to adjust the cruising level of an aircraft operating along an established ATS route extending partly within and partly outside controlled airspace and where the respective series of cruising levels are not identical, such adjustment shall, whenever possible, be effected within controlled airspace and, if suitably located, over a radio navigation aid.

When an aircraft has been cleared into a centre's control area at a cruising level which is below the established minimum cruising level for a subsequent portion of the route, action should be initiated by that area control centre to issue a revised clearance to the aircraft even though the pilot has not requested the necessary cruising level change.

When necessary, an aircraft may be cleared to change cruising level at a specified time, place or rate.

In so far as practicable, cruising levels of aircraft flying to the same destination shall be assigned in a manner that will be correct for an approach sequence at destination.

An aircraft at a cruising level shall normally have priority over other aircraft desiring that cruising level. When two or more aircraft are at the same cruising level, the preceding aircraft shall normally have priority.

An aircraft may be assigned a level previously occupied by another aircraft after the latter has reported vacating it. If, however, severe turbulence is known to exist, or the aircraft concerned is effecting a cruise climb, such assignment shall be withheld until the aircraft vacating the level has reported at another level separated by the required minimum.

Vertical separation during ascent or descent
Pilots in direct communication with each other may, with their concurrence, be cleared to maintain a specified vertical separation between their aircraft during ascent or descent.

8.2.2 Horizontal separation

Lateral separation

Lateral separation application

Lateral separation shall be applied so that the distance between those portions of the intended routes for which the aircraft are to be laterally separated is never less than an established distance to account for navigational inaccuracies plus a specified buffer. This buffer shall be determined by the appropriate authority and included in the lateral separation minima as an integral part thereof.

Lateral separation of aircraft at the same level is obtained by requiring operation on different routes or in different geographical locations as determined by visual observation, by the use of navigation aids or by the use of area navigation equipment.

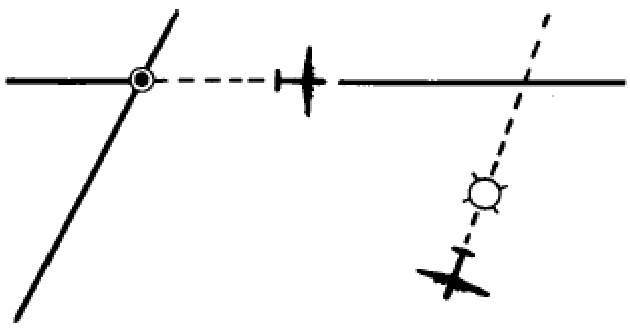
When information is received indicating navigation equipment failure or deterioration below the navigation performance requirements, ATC shall then, as required, apply alternative separation minima.

Lateral separation criteria and minima

Means by which lateral separation may be applied include the following:

Using the same or different geographic locations.

By position reports which positively indicate the aircraft are over different geographic locations as determined visually or by reference to a navigation aid (picture 20).



Picture 20

Using the same navigation aid or method.

By requiring aircraft to fly on specified tracks which are separated by a minimum amount appropriate to the navigation aid or method employed as follows:

a) VOR: at least 15 degrees and at a distance of 28 km (15 NM) or more from the facility;

b) NDB: at least 30 degrees and at a distance of 28 km (15 NM) or more from the facility;

c) dead reckoning (DR): aircraft established on tracks diverging by at least 45 degrees and at a distance of 28 km (15 NM) or more from the point of intersection of the tracks, this point being determined either visually or by reference to a navigation aid and both aircraft are established outbound from the intersection;

d) RNAV operations: aircraft established on tracks which diverge by at least 15 degrees. Lateral separation exists when the protected airspace associated with the track of one aircraft does not overlap with the protected airspace associated with the track of the other aircraft. This is determined by applying the angular difference between two tracks and the appropriate protected airspace value. The derived value is expressed as a distance from the intersection of the two tracks at which lateral separation exists.

When aircraft are operating on tracks which are separated by considerably more than the foregoing minimum figures, States may reduce the distance at which lateral separation is achieved.

Using different navigation aids or methods.
Lateral separation between aircraft using different navigation aids, or when one aircraft is using RNAV equipment, shall be established by ensuring that the derived protected airspaces for the navigation aid(s) or RNP do not overlap.

RNAV operations (where RNP is specified) on parallel tracks or ATS routes.
Within designated airspace or on designated routes, where RNP is specified, lateral separation between RNAV-equipped aircraft may be obtained by requiring aircraft to be established on the centre lines of parallel tracks or ATS routes spaced at a distance which ensures that the protected airspace of the tracks or ATS routes does not overlap.

Transitioning into airspace where a greater lateral separation minimum applies.
By requiring aircraft to fly on specified tracks:

a) which are separated by an appropriate minimum; and then

b) diverge by at least 15 degrees until the applicable lateral separation minimum is established; and

c) it is possible to ensure, by means approved by the appropriate ATS authority, that aircraft have the navigation capability necessary to ensure accurate track guidance.

Longitudinal separation
- Longitudinal separation application
Longitudinal separation shall be applied so that the spacing between the estimated positions of the aircraft being separated is never less than a prescribed minimum. Longitudinal separation between aircraft following the same or diverging tracks may be maintained by application of the Mach number technique, when so prescribed on the basis of regional air navigation agreement.
Longitudinal separation shall be established by requiring aircraft to depart at a specified time, to lose time to arrive over a geographical location at a specified time, or to hold over a geographical location until a specified time.
Longitudinal separation between supersonic aircraft during the transonic acceleration and supersonic phases of flight should normally be established by appropriate timing of the start of transonic acceleration rather than by the imposition of speed restrictions in supersonic flight.

For the purpose of application of longitudinal separation, the terms *same track, reciprocal tracks* and *crossing tracks* shall have the following meanings:

a) Same track (see ANNEX F, picture F-A): same direction tracks and intersecting tracks or portions thereof, the angular difference of which is less than 45 degrees or more than 315 degrees, and whose protection areas overlap.

b) Reciprocal tracks (see ANNEX F, picture F-B): opposite tracks and intersecting tracks or portions thereof, the angular difference of which is more than 135 degrees but less than 225 degrees, and whose protection areas overlap.

c) Crossing tracks (see ANNEX F, picture F-C): intersecting tracks or portions thereof other than those specified in a) and b) above.

- *Longitudinal separation minima based on time*

Aircraft at the same cruising level

Aircraft flying on the same track:

a) 15 minutes (see ANNEX F, picture F-D); or

b) 10 minutes, if navigation aids permit frequent determination of position and speed (see ANNEX F, picture F-E); or

c) 5 minutes in the following cases, provided that in each case the preceding aircraft is maintaining a true airspeed of 37 km/h (20 kt) or more faster than the succeeding aircraft (see ANNEX F, picture F-F):

i) between aircraft that have departed from the same aerodrome;

ii) between en-route aircraft that have reported over the same exact reporting point;

iii) between departing and en-route aircraft after the en-route aircraft has reported over a fix that is so located in relation to the departure point as to ensure that five-minute separation can be established at the point the departing aircraft will join the air route; or

d) 3 minutes in the cases listed under c) provided that in each case the preceding aircraft is maintaining a true airspeed of 74 km/h (40 kt) or more faster than the succeeding aircraft (see ANNEX F, picture F-G).

Aircraft flying on crossing tracks:

a) 15 minutes (see ANNEX F, picture F-H); or

b) 10 minutes if navigation aids permit frequent determination of position and speed (see ANNEX F, picture F-I).

Aircraft climbing or descending

Traffic on the same track.

When an aircraft will pass through the level of another aircraft on the same track, the following minimum longitudinal separation shall be provided:

a) 15 minutes while vertical separation does not exist (see ANNEX F, picture F-J and F-K); or

b) 10 minutes while vertical separation does not exist, provided that such separation is authorized only where navigation aids permit frequent determination of position and speed (see ANNEX F, picture F-L and F-M); or

c) 5 minutes while vertical separation does not exist, provided that the level change is commenced within 10 minutes of the time the second aircraft has reported over an exact reporting point (see ANNEX F, picture F-N and F-O).

Traffic on crossing tracks:

a) 15 minutes while vertical separation does not exist (see ANNEX F, picture F-P and F-R); or

b) 10 minutes while vertical separation does not exist if navigation aids permit frequent determination of position and speed (see ANNEX F, picture F-S and F-T).

Traffic on reciprocal tracks

Where lateral separation is not provided, vertical separation shall be provided for at least ten minutes prior to and after the time the aircraft are estimated to pass, or are estimated to have passed (see ANNEX F, picture F-U). Provided that it has been determined that the aircraft have passed each other, this minimum need not apply.

- Longitudinal separation minima based on distance using RNAV

Separation shall be established by maintaining not less than the specified distance between aircraft positions as reported by reference to RNAV equipment. Direct controllerpilot communications should be maintained, while such separation is used. Where high frequency or general purpose extended range very high frequency air-ground communication channels are used for area control service and are worked by air-ground communicators, suitable arrangements shall be made to permit direct controller-pilot communications, or monitoring by the controller of all air-ground communications.

To assist pilots to readily provide the required RNAV distance information, such position reports should, wherever possible, be referenced to a common way-point ahead of both aircraft.

RNAV distance-based separation may be applied between RNAV-equipped aircraft when operating on designated RNAV routes or on ATS routes defined by VOR.

A 150 km (80 NM) RNAV distance-based separation minimum may be used on same-direction tracks in lieu of a 10-minute longitudinal separation minimum. When applying this separation minimum between aircraft on samedirection track, the Mach number technique (MNT) shall be applied, and the preceding aircraft shall maintain a Mach number equal to or greater than that maintained by the following aircraft.

Turbo-jet aircraft shall adhere to the Mach number approved by ATC and shall request ATC approval before making any changes thereto. If it is essential to make an immediate temporary change in the Mach number (e.g. due to turbulence), ATC shall be notified as soon as possible that such a change has been made.

If it is not feasible, due to aircraft performance, to maintain the last assigned Mach number during en-route climbs and descents, pilots of aircraft concerned shall advise ATC at the time of the climb/descent request.

RNAV distance-based separation minima shall not be applied after ATC has received pilot advice indicating navigation equipment deterioration or failure.

Aircraft at the same cruising level

Aircraft on the same track. (See ANNEX F, picture F-V) A

150 km (80 NM) RNAV distance-based separation minimum may be used provided:

a) each aircraft reports its distance to or from the same "on-track" way-point; and

b) separation is checked by obtaining simultaneous RNAV distance readings from the aircraft at frequent intervals to ensure that the minimum will not be infringed.

Aircraft climbing or descending on the same track

A 150 km (80 NM) RNAV distance-based separation minimum may be used while vertical separation does not exist, provided:

a) each aircraft reports its distance to or from the same "on-track" way-point;

b) one aircraft maintains a level while vertical separation does not exist; and

c) separation is established by obtaining simultaneous RNAV distance readings from the aircraft (see ANNEX F, picture F-W and F-X).

Aircraft on reciprocal tracks

Aircraft utilizing RNAV may be cleared to climb or descend to or through the levels occupied by other aircraft utilizing RNAV provided that it has been positively established by simultaneous RNAV distance readings to or from the same "on-track" way-point that the aircraft have passed each other by at least 150 km (80 NM) (see ANNEX F, picture F-Y).

9. LOOK TO THE NEAR FUTURE

In this last part of my work I would like to attend to few themes, I talked before. But now I will try to give you the overview of what is probably going to happen in the future.

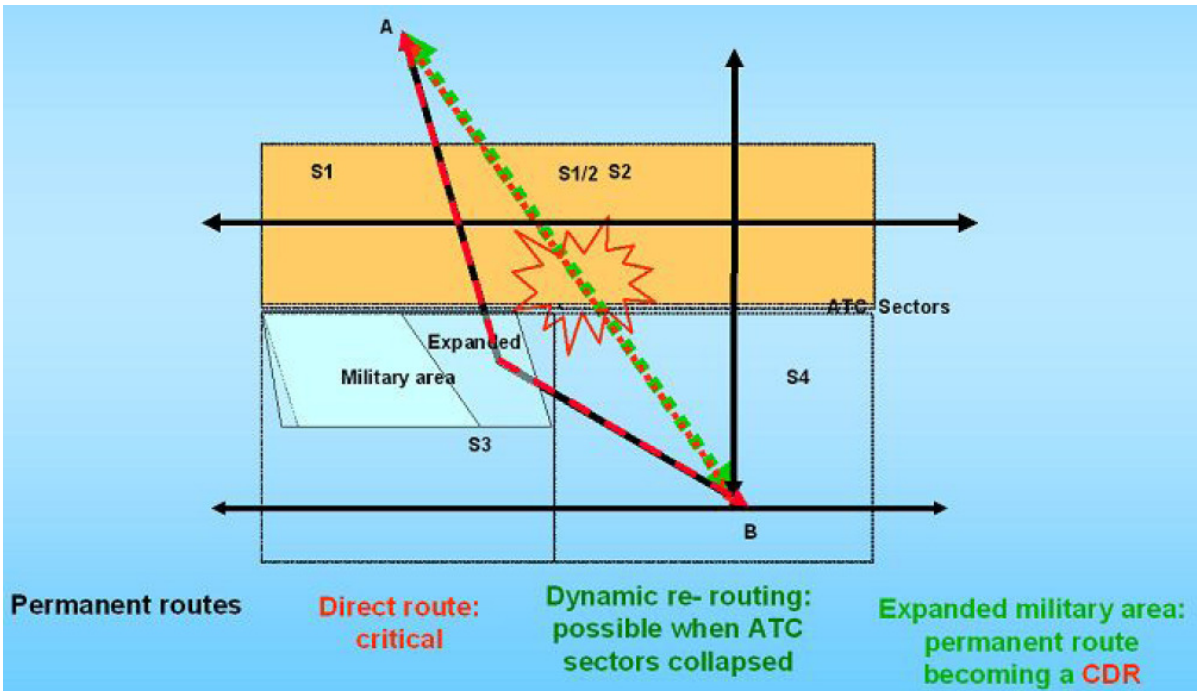
9.1 Future AFCM

Segregated airspace

The integration of military activity into the airspace design process will offer greater flexibility and efficiency. However, is many situations, congestion in the route network is not caused by military airspace requirements but the need to sectorise airspace around controller capabilities.

In this example, the basic route network between points A and B is not efficient. However, a direct routing is not possible since the conflict points would be too close to the sector boundaries. It is possible to consider situations, however, when the traffic levels are such that the 2 sectors could be collapsed. In this case, the direct routing could be made available at the planning stage.

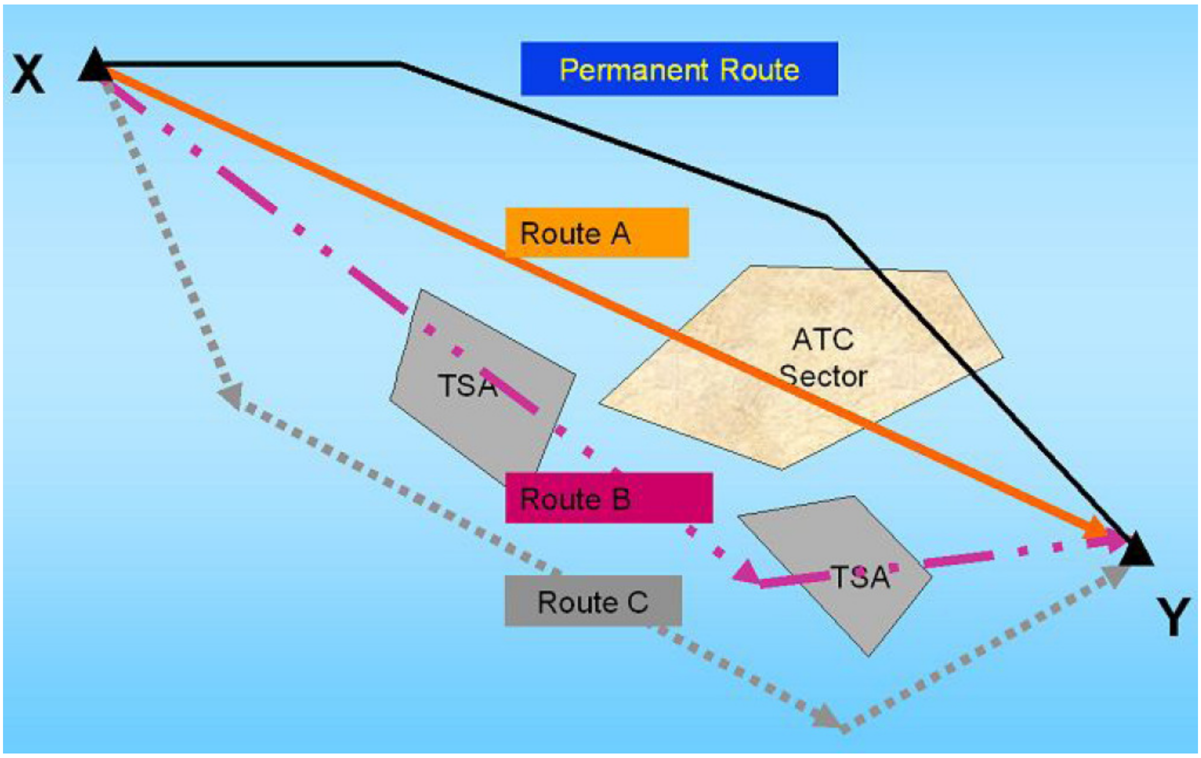
Additionally, the availability of a direct route under some circumstances would enable the longer route to be closed allowing the military to operate in a larger volume of airspace.



Picture 21: Segregated airspace

Future airspace

So how might this work in practise? In this fictitious airspace, there is a permanent route from X to Y through a capacity constrained sector. Additionally, there is a direct route from X to Y through the sector which is available under certain circumstances. Additionally, a conditional route is available through the military training areas and another permanent, but longer route (C) always available.



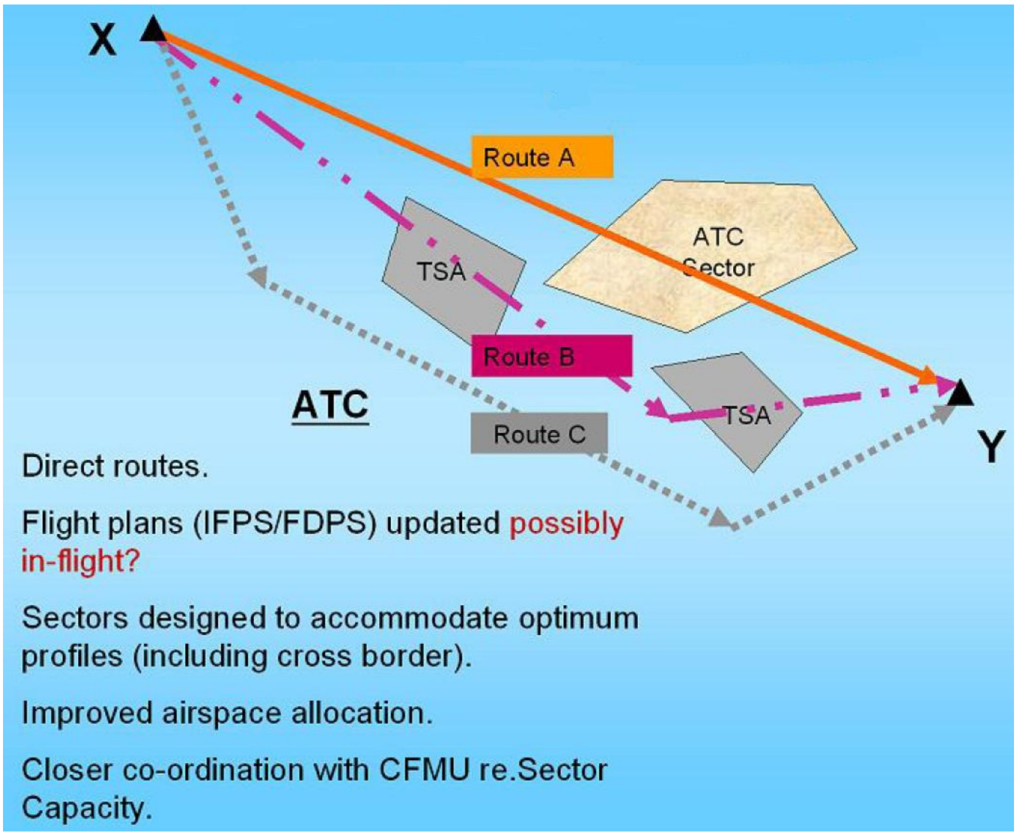
Picture 22: How might future airspace work?

From a civil operator's perspective more route options are potentially available. Additionally, a network management of capacity will ensure that there are fewer restrictions. Decision on which route is flown can be taken closer to Estimated Time of Departure so that fuel/mileage can be correctly balanced.

The optimum profile will be achieved through new sectorisation and better controller tools removing unnecessary standing agreements. This airspace design will best reward operators who can plan flights dynamically and will result in the continued demise of Repetitive Flight Plans.

From an ATC perspective, direct routings currently offered tactically will be made available at the planning stage. Therefore, it will be easier to plan sector loads and the traffic will be more predictable. Nevertheless, tactical direct routings will also be permitted, subject to network considerations. Improvements to IFPS and FDPS will allow flight plans to be updated and the information disseminated to affected parties.

Sectors will be designed to accommodate optimum profiles whilst a more dynamic sectorisation concept will ensure an optimum spread of traffic across controller capacity. The choice of sectorisation will be more collaborative with the CFMU and ACC working together to optimise capacity for all airspace users.



Picture 23

9.2 Future ATS

Current problems

- fragmented collection of actors throughout the phase of flight
- inefficient use of airport surface
- inefficient airspace structure
- en-route capacity restricted by human element

9.2.1 Departure phase

Runway capacity is considered as a principal constraint in to-day's air traffic control system. Several problems exist with regard to optimising departure sequences. Uncertainties of pushback, start-up and taxi times limit the capability of aerodrome control to achieve their preferred sequence. Several actors can influence the sequence of the departures, with each actor seeking to apply local and individual optimisation resulting in a potential for under utilisation of the runway.

Automated support to departure management aims at eliminating the individualised planning and optimisation functions carried out by the individual actors. Automated support to air traffic controllers at European airports will be provided by optimising the sequence of departures for one or more runways and providing advisories to controllers.

The DMAN calculated departure schedule will exploit runway capacity, be CFMU-slot-compliant and take into account airline and airport preferences. It will also comply with constraints such as the departure rates into specific directions or minutes-in-trail or miles-in-trail minima for specific SIDs.

Collaborative decision making principles will be applied to departure management automation.

Controllers will have to respect the sequencing advisories provided by the automated system. However interactivity between controllers and DMAN will be required.

Criterion	Benefit statement	Impact
Safety	Marginal increase of safety (wake vortex separation)	Low
Capacity	Optimisation of departure sequence will allow better utilisation of available runway capacity	Medium
Efficiency	Better timing of aircraft movements will improve ATC efficiency. Earlier detection of problems of integrating departures at TMA exit points will improve overall ATC efficiency	Low
Environment	Further reduction of noise and gas emissions at airports	Low

Table 6: Benefits

9.2.2 En-route phase

Future ATC planning

- sectors opened/sized according to traffic demand
- sector planner co-ordinates conflict-free route through sector
- tactical controller monitors flights and manages exceptions

ATC decision support will be improved in four areas, at sector and multi-sector levels:

- provide automated support for conflict detection;
- provide automated support for conflict detection and resolution;
- provide automated support for detection and resolution of complexity, density and traffic flow problems;

Capacity will be gained by improved task sharing between the planning and tactical controllers. Automatic flight progress monitoring and medium term conflict detection are important means to achieve this goal. In particular, conflict detection is an enabler for a different use of airspace with new procedures for the application of free routes. Within a free route environment conflict detection will become very cumbersome without high-performance conflict detection tools.

Conflict detection as explained in the previous section only provides indications of possible conflicts.

The next improvement after the automation of conflict detection will be automated calculation of conflict resolution advice.

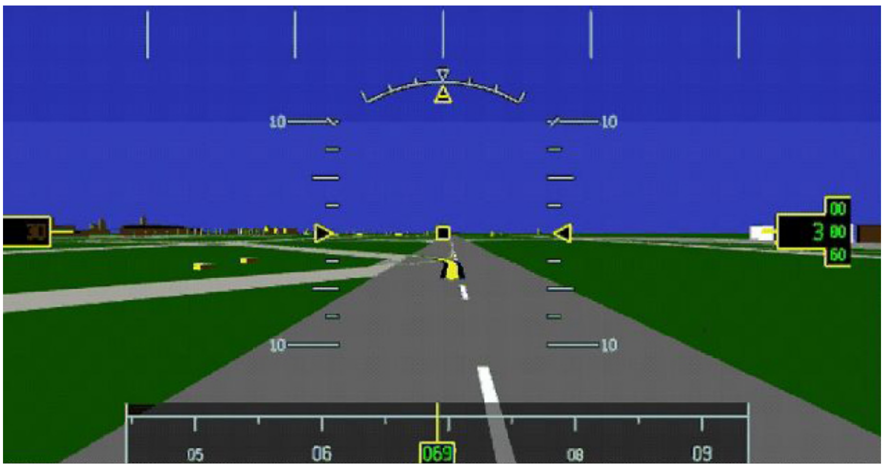
- the next step after detection conflicts is to aid the controller with resolution advice
- the system will be able rapidly assess all options and present the best to the controller.

Apart from conflict detection and resolution, additional support tools will be developed for decreasing controller workload, specifically in a multi-sector/multi-unit environment. In particular these tools will assist controllers in alleviating :

- Traffic complexity
- Traffic density
- Traffic flow problems

The use of tools under this operational improvement area will extend the capability of planning controllers to detect and resolve complexity, density and traffic flow problems within a centre airspace and over the border of the own ATC unit within an area of interest.

9.2.3 Landing phase



Picture 24: Taxiing at the airport in the future – Primary Flight Display

Picture 25: Taxiing at the airport in the future – Navigation Display

<u>9.3 UAVs</u>

This is very young and specific branch in flying, but it already exists and represents brand new way of comprehension of the air traffic.

In present situation it is not easy to implement UAVs to ordinary everyday traffic. Actually it is not a problem in technical way. This is more legislative problem.

I think UAVs represents the future in flying. They can fly VFR, IFR in all kinds of weather and as a benefit, without human error (human factor) on board.

We should be better ready to this turnover in flying…

10. CONCLUSIONS

I think you will agree with me when I say that flying is the quickest and safest, simply the best way how to move from one point to another, anywhere on the planet. This is possible thanks to great progress in last few decades. The flying became safer, more agile and last but not least more open to passengers.
It is more than obvious that a lot of new challenges are set in the future, with which flying have to go through. One of these problems is the capacity which forms last few years.
Because we are just humans – it means we make mistakes, it is necessary to develop those systems which will help us to split our tasks or help us with recognition of the targets.
In section 8 and 9 I focused on flight phases for more reasons. One of them (maybe the most significant) is to name points during the flight, in which the risk of mishap can be high. It means above all the points with high traffic density.
To solve these problems and to help air traffic controllers, some measurements over significant points are needed. Because just in case we will know all about the situation we can react correctly from a humans' point of view and in short time period.

ABBREVIATIONS

AAS	Advanced Airspace Scheme
ACC	Area Control Centre
ACFT	Aircraft
ADP	ATFM Daily Plan
ADREP	Accident Data Reporting
ADS	Automatic Dependent Surveillance - Broadcast
AGL	Above Ground Level
AIC	Aeronautical Information Circular
AIP	Aeronautical Information Publication
ANS	Air Navigation Services
APATSI	Airport/Air Traffic System Interface
APO	Airport Operator
APP	Approach
ARDEP	Analysis of Research and Development in Europe
ASM	Airspace Management
ATC	Air Traffic Control
ATFCM	Air Traffic Flow and Capacity Management
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
ATS	Air Traffic Services
AUP	Airspace Use Plan
CEAC	Committee for European Airspace Co-ordination
CFMU	Central Flow Management Unit
CNS	Communications, Navigation and Surveillance
CNS/ATM	Communication, Navigation, Surveillance/ATM
CTA	Control Area
CTOT	Calculated Take-Off Time
CTR	Control Zone
DA	Danger Area
DME	Distance Measuring Equipment

DR	Dead Reckoning
EA	Europe Airports
EASA	European Aviation Safety Agency
EATCHIP	European Air Traffic Control Harmonisation and Integration Programme
EATMP	European ATM Program
EC	European Commission
ECAC	European Civil Aviation Conference
ECIP	European Convergence and Implementation Plan
ESARR	Safety Regulatory Requirement
ETOT	Estimated Take-Off Time
EU	European Union
EUROCONTROL	European Organisation for the Safety of Air Navigation
FAA	Federal Aviation Administration
FAF	Final Approach Fix
FANS	Future Air Navigation System
FEATS	Future European Air Traffic System
FL	Flight Level
FUA	Flexible Use of Airspace (Concept)
FDP	Flight Data Processing (system)
FIR	Flight Information Region
FMP	Flow Management Position
FMS	Flight Management System
FMU	Flow Management Unit
GAT	General Air Traffic
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
IAF	Initial Approach Fix
ICAO	International Civil Aviation Organisation
IF	Initial Fix
IFR	Instrument Flight Rules
ILS	Instrument Landing System

JAA	Joint Aviation Authorities
MAPt	Missed Approach Point)
MATSE	Transport Ministers' Meeting on the Air Traffic System in Europe
MNT	Mach Number Technique
MTOW	Maximum Take-Off Weight
NLR	National Aerospace Laboratory - The Netherlands
NAV	Navigation
NATO	North Atlantic Treaty Organisation
OAT	Operational Air Traffic
PA	Prohibited Area
PDG	Procedure Design Gradient
RA	Restricted Area
RNAV	Area Navigation
RNP	Required Navigational Performance
RVSM	Reduced Vertical Separation Minimum
RWY	Runway
SID	Standard Instrument Departure
SSR	Secondary Surveillance Radar
STAR	Standard Arrival Route
TA	Terminal Airspace
TMA	Terminal Control Area
TSA	Temporary Segregated Area
TWR	Tower
UAV	Unmanned Aerial Vehicle
UUP	Updated AUP
VFR	Visual Flight Rules
VHF	Very High Frequency
VOR	VHF Omni-directional Range
VSM	Vertical Separation Minimum

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