CNS / ATM Strategy for Business Aviation

29 April, 2005

International Business Aviation Council

General Aviation Manufacturers Association

Executive Summary

Introduction

This report provides the consolidated business aviation recommendations responding to the undertaking of the International Civil Aviation Organization (ICAO) to develop a detailed roadmap for the implementation of Communications, Navigation, Surveillance and Air Traffic Management (CNS/ATM).

The ICAO Air Navigation Commission convened an informal meeting with the aviation industry in May of 2004 at which it was agreed to amend the Global Air Navigation Plan to incorporate a more detailed roadmap for CNS/ATM. The aviation industry members committed to provide comprehensive input.

To respond to the ICAO request, the business aviation community formed a Joint Committee (JC) consisting of business aviation operators and manufacturers. The JC was organized and sponsored by the International Business Aviation Council (IBAC) and the General Aviation Manufacturers Association (GAMA), with extensive assistance provided by respective Members. A number of coordination meetings were held by the JC and a series of presentations made by Air Navigation Service Providers (ANSPs), airframe manufacturers, and avionics integrators. Coordination discussions were held with organizations such as ICAO, the International Air Transport Association (IATA) and RTCA. The JC also reviewed previous work conducted by ICAO, IATA, RTCA, Eurocontrol and others in development of Concepts of Operations.

As a preliminary step to development of the business aviation recommendations, the JC established a number of principles specific to that sector of the industry. These principles included the need to ensure global harmonization through use of common standards and the need for equitable airspace access for all users. A thorough review of all possible capabilities and technologies along with progress being made with each was completed. Alternatives were discussed and conclusions and recommendations were derived.

Business Aviation Community

The business aviation operator community which provided input to the CNS/ATM roadmap consisted of operators of corporate aircraft, on-demand charter, owner-flown aircraft, and fractional ownership. The industry is large, with over 23,000 turbine aircraft operated by over 14,000 companies. The industry has many unique characteristics such as the dynamic and non-scheduled nature of the operations, excellent performance capabilities of the aircraft and different mechanisms for training and provisioning of services for the large number of small flight departments.

The JC evaluation included a review of business aviation operational requirements and user expectations. Given the vast differences in types of business aviation operations and aircraft, the JC addressed all sub-sectors and reviewed requirements for both domestic and international operations. A survey conducted through IBAC Member Associations generated significant user comment, all indicating strong interest in the need for guidance for the industry as well as a position to be established for air navigation service providers and airspace planners.

Concept of Operations Review

The JC also conducted a thorough review of the extensive work conducted by other organizations in refining the vision for CNS/ATM inherent in the many Concepts of Operations documents. The purpose of the comparison was to determine what, if any, conflicts existed between the documents as they related to the desired characteristics of future ATM systems in support of business aviation. No significant contradictions between the documents were found. In general they are all supportive of each other and have many themes in common information sharing being significant.

Goals

The planning for implementation of various enabling technologies, procedures and practices, and infrastructure is under way in varying degrees in the ICAO regions. It is necessary that the implementation be focused with a clear concept of how to integrate those elements into a coherent and seamless global ATM system. It is also essential that the capabilities of existing and future aircraft equipage, air traffic control systems and ATM infrastructure be utilized to the maximum extent possible to deliver transitional benefits while the future system is being defined and developed.

The global ATM system must be developed and organized to overcome the limitations of the current system, and to accommodate future growth, so as to offer the best possible service to all airspace users and to provide adequate economic benefits to the aviation community. The global ATM system must also be developed to ensure harmonization and synchronization of change, so that benefits are maximized.

A goal of the ATM system must be a minimum set of avionics which is usable in all airspace. It is not acceptable to require one set of avionics within one region and a different set in other regions, each performing essentially the same functions. Moreover, if international operators improve their on-board capabilities to exploit ATM service improvements implemented in one State, the return on their investment will be enhanced if the same improvements are implemented in other States. It must also be a goal of the ATM system that infrastructure and avionics no longer required be removed from service.

The operational concept describes the components in a global sense. The end state aims at global harmonization by the concept horizon of 2025. It is recognized that the end state of the operational concept will be reached through a set of evolutionary steps. However, the end state will be a transformed operational concept with improved level of productivity where certain tasks have been re-distributed between people and machines and as appropriate between controllers and pilots.

This allows States, regions and homogeneous areas to plan the significant investments that will need to be made, and the timeframe for those investments, on a partnership basis, and within a framework of safety and a business case. The ATM operational concept also provides the basis from which the ATM operational requirements, objectives and benefits will be derived, thereby providing the foundation for the development of regional and national ATM implementation plans.

Roadmap

In order to enhance collaboration and to enable a more expeditious approach to ATM evolution, potential operational improvements have been grouped into an ATM transition roadmap. The roadmap lays out a set of objectives along the ATM evolution path. This map shows initiatives in a short to medium term timeframe. Short-term is identified as a five to seven year horizon commencing with a base date of 1 January 2005. Medium term is identified as a similar horizon commencing in the 2010 timeframe. The ATM enhancements derived from this roadmap are fundamentally aligned with the future direction enunciated in the ATM Operational Concept. This roadmap is intended to be used by Regions and States to develop more detailed implementation plans.

Considerable investments have been made by ATM community members in developing and equipping with airborne and ground based capabilities, many of which are under-utilized or not utilized at all. It is essential that the capabilities and system capacities offered by existing aircraft equipage, ATM infrastructure and air traffic control systems be utilized to the maximum extent possible to deliver transitional benefits while the future system is being developed.

In assessing solution sets for a particular enhancement, the ATM community must recognize that the common denominator in aviation is the airspace user, and in particular international air transport and many business aviation aircraft, which regularly transit Regions and States. The business aviation users, in accordance with the global goal of seamless ATM, are seeking to carry the minimum defined set of standardized and commonly applied avionics and equipment.

Conclusions and Recommendations

The conclusions and recommendations of the report are aimed at achieving the goal of a safe, secure, cost effective, and harmonized global air navigation plan providing for an air navigation system that is equally available to all users. This objective can only be realized through mutually complementary decisions and actions of the various partners. Consequently, the recommendations are addressed to ICAO, the business aviation operators, ANSPs, and the airframe and avionics manufacturers.

Recommendations to International Civil Aviation Organization

Communications	Navigation	Surveillance	System Integration
• Advocate that Regional Planning Groups establish realistic and coordinated implementation schedules that consider the needs of all classes of users • Advocate that ANSPs harmonize on Controller Pilot Data Link Communication (CPDLC) message set and procedures • Update Regional Supplementary Procedures (Doc 7030) to accommodate use of Satellite Communications (SATCOM) voice for routine oceanic/remote communications in all regions • Simplify and rationalize regulatory processes for operational approvals	• Advocate that Regional Planning Groups establish realistic and coordinated implementation schedules that consider the needs of all classes of users • Renew initiatives to promote WGS-84 implementation by all States • Simplify and rationalize regulatory processes for operational approvals (Reduced Vertical Separation Minima [RVSM], Required Navigation Performance [RNP], etc.) • Strengthen procedures for transition between Flight Information Regions (FIRs) using feet and metres. • Stress the need for certain States to implement ICAO standards in FIRs using metric units for flight levels • Urge implementation of RNAV/RNP terminal area and approach procedures including airports utilized by business aviation	• Advocate that Regional Planning Groups establish realistic and coordinated implementation schedules that consider the needs of all classes of users • Advocate that ANSPs provide Automatic Dependent Surveillance - Broadcast (ADS-B) using 1090 MHz Extended Squitter (1090ES) • Urge use of Future Air Navigation System (FANS) Automatic Dependent Surveillance - Contract (ADS-C) for enhanced surveillance in oceanic/remote airspace	• Advocate that Regional Planning Groups establish realistic and coordinated implementation schedules that consider the needs of all classes of users

Recommendations to Business Aviation Operators

Communications	Navigation	Surveillance	System Integration
Voice • Continue to provision 8.33 kHz only to support European operations • Expand participation in NAT or other SATCOM voice programs Data link • Implement FANS CPDLC capability on aircraft for frequent oceanic/remote operations to enhance safety and preserve airspace access • Implement Aeronautical Telecommunications Network (ATN) CPDLC capability as appropriate (i.e. Link2000+) on European domestic aircraft when sufficient benefits are established • Utilize data link for other Air Traffic Services (ATS) (e.g. DCL, D-ATIS, OCL) • Ensure timely and effective flight crew training is implemented for data link communication systems	Aircraft/FMS Upgrade • Install containment based RNP capability • Install Required Time of Arrival (RTA) capability as needed to support optimized arrival procedures or similar enhancements in air operations • Advocate the development of RNAV/RNP terminal area procedures • Ensure timely and effective flight crew training is implemented for navigation systems	Mode S • Install Elementary Surveillance capability to support operations where required • Install Enhanced Surveillance capability to accommodate European mandate (2007), or when waivers are no longer available • Install 1090ES on new aircraft for ADS-B and retro-fit on an opportunistic basis Data link (ADS-C) • Implement FANS capability on aircraft for oceanic/remote operations to enhance safety and preserve airspace access • Ensure timely and effective flight crew training is implemented for surveillance systems	• Explore opportunities to achieve Collaborative Decision Making (CDM) participation • Consider equipage with systems that enhance situational awareness (e.g. graphical weather, Head Up Display [HUD] and Enhanced Vision System [EVS])

Recommendations to Airframe and Avionics Manufacturers

Communications	Navigation	Surveillance	System Integration
Ensure timely availability of: • engineering, documentation, and/or Supplemental Type Certificates (STCs)/Service Bulletins (SBs) to support new aircraft deliveries and system upgrades on existing aircraft • training and associated documentation.	Ensure timely availability of: • engineering, documentation, and/or STCs/SBs to support new aircraft deliveries and system upgrades on existing aircraft • training and associated documentation.	Ensure timely availability of: • engineering, documentation, and/or STCs/SBs to support new aircraft deliveries and system upgrades on existing aircraft • training and associated documentation.	• Integrate CNS functionality within aircraft/ground architectures to ensure operational and cost effective solutions

Recommendations to Air Navigation Service Providers

<table>
<tr><th>Communications</th><th>Navigation</th><th>Surveillance</th><th>System Integration</th></tr>
<tr>
<td>Voice
• Do not implement 8.33 kHz except in Europe
• Accept and expand the use of SATCOM voice for routine oceanic /remote communications

Data link (CPDLC)
• Develop plans to accommodate both FANS CPDLC and ATN CPDLC where feasibility while ensuring transparent and consistent operations in all regions
• Harmonize on CPDLC message set and procedures
• Implement data link for other ATS services (e.g. DLC, D-ATIS, OCL)</td>
<td>• Implement WGS-84
• Strengthen procedures for transition between FIRs feet and metres.
• States using metric units for flight levels are urged to implement ICAO standards
• Implement RNAV/RNP terminal area and approach procedures including airports utilized by business aviation
• Develop, in consultation with users, plans to phase out obsolete ground-based navigation facilities</td>
<td>• Utilize 1090ES for ADS-B communication (refrain from imposing additional data link technologies)
• Migrate from time based to distance based separation in oceanic/remote areas
• Consider alternatives to radar such as multilateration to enhance safety using existing on-board avionics
• Utilize FANS ADS-C for enhanced surveillance in oceanic/remote airspace</td>
<td>• Integrate CDM processes to accommodate business operators
• Develop integrated decision making system/procedures to enable real-time flight plan updates to enhance enroute and terminal area efficiency</td>
</tr>
</table>

The Joint Committee recognizes that technology and concepts for CNS/ATM are advancing very rapidly. The industry must remain ready to embrace new ideas and to work on standards for new equipment and procedures. The plan must be dynamic, yet recognize the impact on the industry when technology is mandated without thorough planning and assessment of cost benefit. The Committee therefore concludes that the JC should reconvene in two to three years to review progress on the implementation of CNS/ATM and to determine if adjustments are required in the business aviation industry recommendations.

Table of Contents

1. Introduction

1.1 Purpose

The worldwide aviation community has committed extensive time and energy since the early 1980s towards the design of a safe and efficient air navigation system (ANS) for the future. Visionary plans have been examined and discussed, leading to the community endorsement of the concepts promulgated by the ICAO, ANSPs, and airspace users. Evolution of the vision through assessment of various CNS/ATM options has now reached a point where more detailed planning is required.

This report was developed by the business aviation operating and manufacturing industries to provide input to ICAO and other bodies on recommendations for development of a detailed roadmap for the future air navigation system. The objective is a harmonized business aviation position for integrating input to the global system for oceanic, remote and domestic operations.

The report does not attempt to repeat the visions, expectations and designs expressed in the Concept of Operations Documents produced by ICAO, RTCA and other organizations. Rather, the business aviation community accepts the work of these organizations and offers detailed recommendations responsive to the needs of the business aviation community, but with full recognition of the requirements of other aviation sectors. While IATA documents were taken into account, those documents do not form the basis of business aviation's recommendations.

1.2 Background

In the 1980s, ICAO, Member States, service providers and the aviation user community started work on development of a new plan for managing the world's airspace and navigation systems, taking into account the new emerging technologies. It was recognized that the existing approach of air traffic services and aircraft navigation were limiting capacity and efficiency.

The task of exploring a new dynamic was assigned in 1983 to an ICAO Special Committee on the Future Air Navigation System (FANS), in which IBAC participated. The FANS work culminated in the ICAO 10th Air Navigation Conference in 1991, where the FANS concept was endorsed.

Following acceptance by the ICAO Council, FANS was subsequently renamed the Communications, Navigation, Surveillance / Air Traffic Management (CNS/ATM) concept. Implementation of CNS/ATM was initially planned through a 'Global Coordinated Plan for transition to ICAO CNS/ATM Systems'. Later, with maturation of the concept, a Global Air Navigation Plan for CNS/ATM (ICAO Doc 9750 AN/963) was developed.

In the intervening years it became evident that in order to ensure better use of CNS/ATM technologies and to ensure coordinated implementation, an Operational Concept was needed. The ICAO Air Traffic Management Operational Concept Panel (ATMCP) was formed to develop the Operational Concept, which was produced and then sanctioned by the 11th Air Navigation Conference held in September 2003. The CNS/ATM operational concept covers a large range of institutional, infrastructural, procedural and technological issues. Work is continuing on development of Standards and Recommended Practices that will govern new equipment in the future.

In parallel with this activity and based on Required Navigation Performance (RNP), material was developed and introduced into ICAO PANS ATM (Doc 4444) to accommodate reductions in horizontal separation criteria. Work continues in this field by the ICAO SAS Panel (formerly the RGCS Panel).

Separation based on RNP10 has been implemented in a number of ICAO Regions, including AS/PAC, MID and SAT Regions. Further reductions in horizontal separation based on RNP 4 were implemented in South Pacific in January 2005 and are under consideration in several Regions, including the NAT. Such further reductions will require direct pilot controller communication using data link.

In addition to the adoption of technical characteristics for a number of air-ground 'links', specifications have also been adopted for ADS and CPDLC message sets and related operational procedures. Work continues under the ICAO OPLINK Panel (formerly the ADS Panel).

In 2004, an informal meeting was convened by the ICAO Air Navigation Commission with the aviation industry, at which it was concluded that a detailed plan must be developed for the implementation of CNS/ATM. Among the conclusions of the meeting were:

> *…..that all partners consider the Global Air Navigation Plan (Doc 9750) as the dynamic, high-level framework for the implementation of CNS/ATM systems, and agree to participate in the on-going effort to identify and meet the objectives of the Plan, including agreed time lines and associated commitments.*
>
> *…..that those partners who are in a position to do so, work together toward the development of a common roadmap/global action plan, aimed at attaining operational benefits in the near to medium term and that such a document should be made available to ICAO by mid October 2004, for presentation to the Air Navigation Commission and consideration for inclusion in the Global Plan.*

It is very important that the business aviation community contribute to the development of a detailed implementation plan.

It has become clear through the years of development of the various CNS/ATM plans that the airline industry has been the primary user focal point for technological and procedural development. The airline industry has been extremely active and engaged in planning activities and contributing to work by ICAO and service providers. The business aviation industry has been very active at discussions at the high level, and has presented various papers on the impact of CNS/ATM to business aviation operations. However, since the business aviation industry lacks a cohesive technological planning mechanism, the business aviation industry has not been able to significantly influence the specific planning forums dealing with technologies and procedures.

The business aviation industry is very diverse, with a wide spectrum of manufacturers (as opposed to the two very large manufacturers in the airline industry). Operators are generally small and lack the R&D staff to develop new concepts. With over 15,000 operating companies and over 23,000 turbine powered aircraft, business aviation is significantly large and given the horizontal shape of the industry it is very difficult to coordinate harmonized statements of requirements.

Generally, business aviation has lacked a mechanism to provide leadership in developing a clear statement of operational requirements. Aircraft manufacturers have been looking to the operators to define their requirements; yet operators generally do not have the critical mass in terms of expertise and available staff to provide the input.

A solution to this problem was found through implementation of a Joint Committee made of operators, airframe manufacturers and systems manufacturers and providers. The Joint Committee developed the recommendations contained in this report.

1.3 Development of the Business Aviation Proposal

The Joint Committee (JC) tasked with developing the Business Aviation integrated position was constituted with representation from aircraft operators, the manufacturing industry and ANS service providers. Operating Member representatives were nominated from associations such as the International Business Aviation Council (IBAC), the National Business Aviation Association (NBAA), the Associação Brasileira de Aviação Geral (ABAG), the Brazilian Civil Aviation Authority and the Canadian Business Aviation Association (CBAA). Manufacturer representatives came from the General Aviation Manufacturing Association (GAMA), Honeywell, Dassault, Cessna, Gulfstream and Rockwell Collins. Service providers included ARINC and SITA.

The Terms of Reference (TORs) for the JC are provided in Appendix A.

The Project Manager for the JC was provided through the courtesy of Aeronautical Radio Inc. (ARINC) Industry Activities. Overall guidance and final decision making rested with a Steering Committee consisting of members of the International Business Aviation Council (IBAC) and the General Aviation Manufacturing Association (GAMA).

The JC met on a number of occasions in North America and Europe over a period of six months. The JC methodology was to:

- Review ICAO CNS/ATM Global Plan;
- Review and discuss the status of various Operational Concept Documents;
- Research development programs of service providers and research organizations such as the FAA, NAVCAN, JPDO and others;
- Review developments of various airframe and systems developers;
- Survey operators to determine requirements and existing problems;
- Develop an operational requirement statement;
- Develop a technical development status;
- Review and coordinate with the IATA roadmap;
- Evaluate various options;
- Develop report and review it with the business aviation community; and
- Publish and submit a final report.

A list of JC Members, list of meetings conducted, and a list of the companies and organizations that provided a briefing to various JC meetings are included in Appendix B.

Responsibility for submitting the report to ICAO rests with IBAC and GAMA.

1.4 Basic Principles

The business aviation community concurs and supports the basic principles of a CNS/ATM system as developed in the Operational Concept documents. These include the need to focus on safety, efficiency, environment, global interoperability, flexibility and others. The community also agrees with the fundamental components of the ATM concept of

- Airspace and Organization Management Improvements;
- Aerodrome operations;
- Demand and Capacity Balancing;
- Traffic Synchronization;
- Airspace User Operations;
- Conflict Management; and
- Airspace Service delivery Management.

A number of basic principles were considered by the JC specific to the development of an integrated business aviation position. The detailed roadmap is intended to:

- Enhance Safety and Efficiency – The plan is to recognize the safety and efficiency of aircraft operations.

- Retain Existing ATM Concepts - ATM Operational Concepts developed by other organizations are not to be repeated and these concepts are to serve as the foundation for the business aviation detailed plan.

- Represent the interests of all Business Aviation - The analysis is to represent the interests of the operating and manufacturing arms of business aviation.

- Include all Airspace - Both oceanic (remote) and domestic operations are to be included.

- Cover Short to Medium Term Requirements - The plan is to cover a period up to approximately 15 years.

- Incorporate ICAO SARPs compliant systems and procedures –The implementation plan must call for existing, or to be developed, SARPS for all systems.

- Facilitate Use of Existing Technologies – The plan is to recognize existing technologies for use in the short term as a means of transitioning to the medium and long term.

- Ensure equitable airspace access for all users – Non discrimination is to be considered in the final proposal.

- Establish and adhere to milestones – The plan must contain milestones to provide time and equipment for retrofit.

- Apply Business Case Considerations – All proposals should specify the cost benefits.

1.5 The Joint Committee Report

This report presents the results of the work of the Joint Committee tasked with developing the business aviation community position on the detailed roadmap for the implementation of CNS/ATM systems. The recommendations will be applied to the industry wide proposals for a consolidated user statement.

The report is presented such that it parallels the work of the Joint Committee. This first section provides a brief outline of the reasons for creating the Joint Committee and presents the purpose of the business aviation position. The remaining sections of the report depict considerations as follows:

Section 2 – briefly describes the business aviation community so that there is understanding of the structure and issues faced by the industry and includes a brief outlook.

Section 3 – provides a broad statement of operational requirement, reflecting the needs of the business aviation operating community for the future air navigation system.

Section 4 – provides a summary of the various Concepts of Operations developed by organizations such as ICAO and RTCA, highlighting differences in approach.

Section 5 – provides an ATM evolution where it is essential to use existing aircraft equipage, ATM infrastructure, and air traffic control systems to the maximum extent possible while the future system is being developed.

Section 6 – provides an overview of the ATM transition roadmap.

Section 7 – provides an overview of the use of existing or emerging capabilities to support ATM enhancements.

Section 8 – summarizes the recommendations to be made to ICAO and other organizations in respect of the business aviation community requirements.

Appendix A – IBAC/GAMA Joint Committee Terms of Reference (TORs)

Appendix B – List of Joint Committee Members, Meetings conducted, and Presenters

Appendix C – List of Acronyms

Appendix D – Summary Matrix of Major Characteristics of Various Concepts of Operations Documents

Appendix E – Effecting ATM Change

2. The Business Aviation Community

2.1 Business Aircraft Operators

Business Aviation is the part of general aviation and small on-demand commercial operations that applies to aircraft used for business purposes. It is a relatively large, complex and diverse community with a range of aircraft from small and unsophisticated to very advanced jet aircraft capable of intercontinental travel.

Business aviation falls under three broad categories:

1. Corporate;
2. On-demand charter; and
3. Owner flown.

Fractional ownership is another well established form of business aviation that could fit into either corporate or on-demand charter depending on how the respective States regulate the operations.

Corporate aviation consists of non-commercial, professionally flown aircraft ranging from small turbo-propeller driven aircraft to large ultra long range modern jet aircraft. These are dual pilot operations. Corporate operations are often conducted into both the high-density terminal and upper level airspaces. Many companies operate the aircraft on intercontinental oceanic routes. The aircraft are generally well equipped with modern avionics and communications equipment.

On-demand charter aircraft used for business purposes also feature a range of sizes, but they tend to be smaller aircraft such as the many versions of single and twin engine turboprop and light turbojet/turbofan aircraft. Also included in this group are aircraft owned and operated by a company much the same as a corporate aircraft, but for many possible reasons, the company has chosen to obtain a commercial Air Operators Certificate (more common in some countries of Europe). On-demand operations can be conducted into both remote areas as well as high-density terminal areas.

Owner flown aircraft are generally smaller and sometimes certified for single pilot operations. These aircraft are almost universally certified at less than 5,700 kgs (12,500 lbs) and would normally be limited to short range domestic or cross border operations. It is less likely that these aircraft will be operated into high-density terminal areas, but it does occur. Navigation and communications equipment on older aircraft are generally very basic, whereas due to significantly reduced costs of general aviation avionics equipment, newer aircraft tend to feature more sophisticated satellite navigation systems.

Fractional Ownership represents a relatively new application of business aviation. In some countries fractional ownership is considered non-commercial and in others it is commercial. Again, the range and size of the aircraft varies considerably, but given the very young age (originated in 1987) of fractional ownership, essentially all aircraft are modern and well equipped. The total number of fractional aircraft in 2004 was 870 and there is positive indication that the fleet will continue to grow.

The business aviation community is unique in that both the number of aircraft and the number of operators are large. In 2004 there were over 23,000 turbine aircraft, operated globally by over 15,000 companies. The average number of aircraft is 1.6. Since many flight departments have a number of aircraft it is evident that the great majority of companies have only one aircraft.

The breakdown by region of the world indicates that the great majority of aircraft are in North America.

Fleet by Region (2004)			
Region	**Turbo Jet**	**Turbo Prop**	**Total**
Africa	264	410	656
Asia	461	392	853
Central America	536	325	861
Europe	1,512	905	2,417
North America	10,165	7,050	17,215
Oceania	87	208	295
South America	510	1,063	1,573
Total	13,517	10,385	23,870

Courtesy of Robert E. Breiling Associates, Inc.

Aircraft size serves as an indicator of intercontinental capability as medium and large jets are generally capable of intercontinental flight. In 2003 there were approximately 6,550 medium to large jet aircraft.

Large Jet aircraft	2,914
Medium Jets	3,642
Light Jets	5,849

If it is assumed that turbo propeller aircraft will generally have a shorter range, the total number of aircraft likely limited to domestic and cross-border operations would be 16,202 (10,353 turbo props and 5,849 jets).

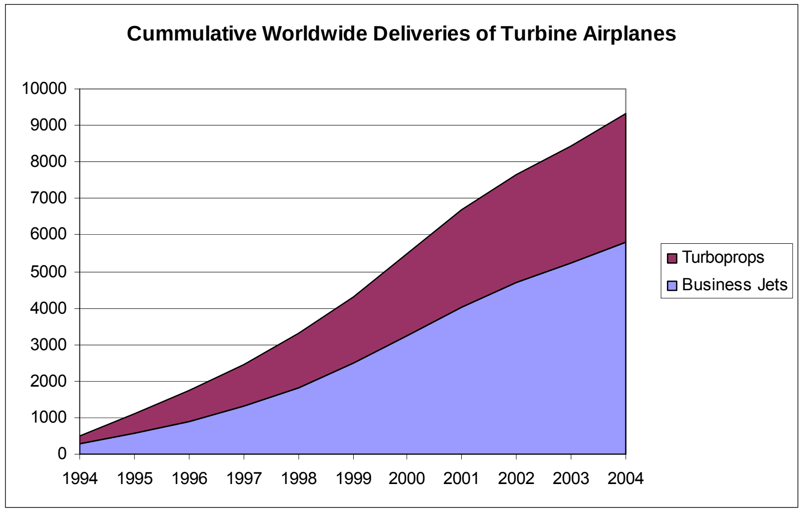
Business aircraft tend to fly at higher altitudes on intercontinental routes. Studies have indicated that above FL410, over 50% of the traffic is business aircraft.

Some unique features of business aircraft operations are as follows:

1. Business Jet aircraft are generally certified to operate at levels higher than air carrier aircraft (some to 51,000 ft).
2. The aircraft are capable of high rates of climb to higher altitudes, without the need to step climb.
3. Runway occupancy time is less than for larger air carrier aircraft.
4. Business aircraft operating on oceanic routes will generally make only a couple of round trips per year.
5. Destinations are random, depending on the dynamic business needs of the company, thus limiting the ability to use canned routes and flight plans.
6. Operations generally occur on short notice.
7. Flight planning and provision of AIS services on intercontinental operations are often provided by service providers specializing in service to corporate operators (there is generally insufficient critical mass for business aviation flight departments to have their own flight planning office).

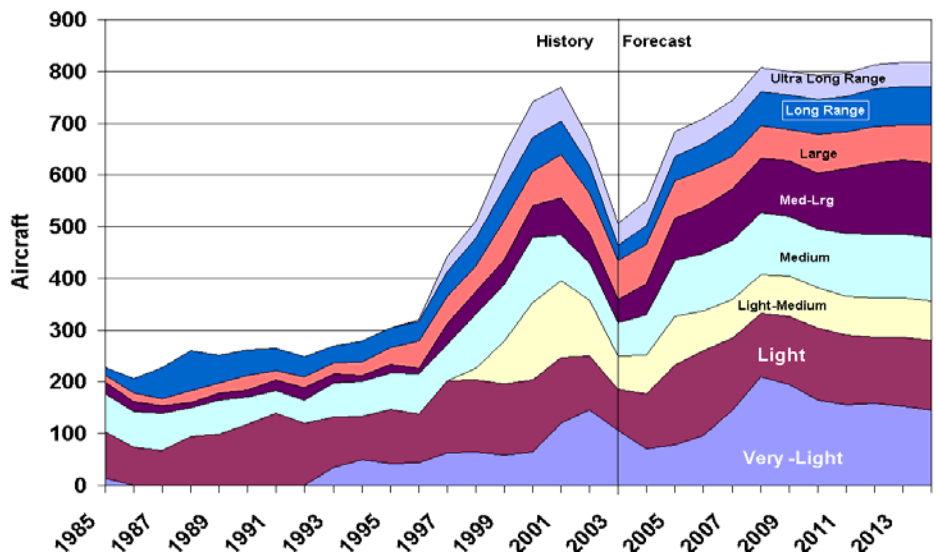
History and Outlook

The worldwide business aviation fleet has seen tremendous growth starting in the mid-1990s. The business jet was introduced to the world in the early 1960s, but more than 40 percent of the world's business jets were produced the past ten years.



The forecast for business jet sales is also indicating a bright future. According to Honeywell, over the next five years the world wide market for new business jets exceeds 3,450 aircraft. However, while North America dominates the market with 74 percent, Europe accounts for 11 percent, Asia for 9 percent and Latin America for 6 percent. The business turbo prop market accounts for 700-850 aircraft over the same period of time with 43 percent going to North America, 42 percent to Asia, 11 percent to Europe, and 4 percent to Latin America.

Executive Turbofan Deliveries



Source: Honeywell 2004

Business aviation is also increasingly becoming a tool that facilitates international business and trade. As an example, over the past five years the industry has seen a 45 percent increase in the number of business jets that depart on oceanic flight plans across the Pacific Ocean according to FAA air traffic data. Similar traffic growth is seen around the world.

Regional traffic, such as that in the United States, is also primed to grow at a steady pace. According to the FAA's most recent outlook, turbine operations will grow from 4.6 million hours in 2004 to 7.8 million hours by 2015, an increase by 68 percent.

3. Operational Requirements and User Expectations

3.1 Members of the ATM community will have differing views and varying degrees of expectations of the system. For optimum performance, airspace management, safety and operational requirements must be balanced which will best be accomplished through partnership and cooperation. Ultimately, what is desired is a cost effective, secure, safe and harmonized global air navigation plan providing a system that is equally available to everyone.

3.2 The global air navigation system should allow airspace access to all users. As regions and/or states transition from voice and radar based systems to data link, provision should be made for phase in of new systems and procedures, ensuring equity in airspace access to all user segments within the operational constraints of the state. Capacity driven reductions in separation based on new technologies should not lead to the exclusion of any user segment from any airspace. To the maximum extent possible, all stakeholders should be given the opportunity to be involved in the allocation of resources.

3.3 Air traffic service providers should exploit every opportunity to expand capacity and efficiency in accordance with the global air navigation plan. As new technologies are implemented it is very important that every effort be made to harmonize procedures and equipment requirements in all regions of the world. Harmonization will help insure Safety, Cost Effectiveness, and Global Interoperability. In all cases, these factors must take into account all members of the ATM community, users and providers alike. With regard to technology, we must always keep an eye on the future with the thoughts of a culture of Continuous Improvement.

3.4 The Communication, Navigation, and Surveillance (CNS) technology deployment strategies will:

a. Be safety-led, i.e. changes will be planned with reference to their likely impact on the Target Level of Safety (TLS) and will proceed only if the TLS conformance can be achieved at all stages of development.
b. Be structured in such a way as to allow users and providers to develop flexible plans to accommodate the strategy at a time, which fits with their business plans. This will require the ability to provide differing levels of service, which will allow the most modern aircraft to benefit from their avionics fit, without penalizing those without the necessary equipment.
c. Avoid mandating particular equipage unless necessary to maintain safety and/or to achieve the desired ATM system benefits (e.g. through cost/benefit analysis).
d. Be based on making use of solutions which are currently available or will be in the short term, while taking into account long term aims in accordance with the Global ATM Operational Concept.
e. Adapt to emerging technologies in response to reasonable levels of customer demand

3.5 To meet increasing airspace demand, technology, procedures, training and aircraft equipage must continue to move forward.

3.6 In the formulation of the views represented by the operators the results of an operator's survey on CNS/ATM issues was used. An on-line survey was distributed to the IBAC members. The Brazilian Aviation Authority also conducted a direct mail campaign in South America. There were 450 responses representing all IBAC member associations. The nominal respondent indicated a fleet size of 1 to 5 aircraft. The results of the survey indicated that safety and access were the primary issues. The majority of respondents indicated they would retrofit or upgrade their existing fleets to receive benefits associated with the new technologies.

4. Summary of the Various Concepts of Operations

4.1 Three major concepts of operations documents were compared in support of the JC efforts: ICAO Global Operational Concept, which was produced and then sanctioned by the 11th Air Navigation Conference held in September 2003; the European Air Traffic Management for the Years 2000+, and the RTCA National Airspace System Concept of Operations.

4.1.1 The purpose of the comparison was to determine what, if any, conflicts existed between the documents as they related to the desired characteristics of future ATM systems in support of business aviation. No significant contradictions between the documents were found. In general they are all supportive of each other and have many themes in common, common information sharing being a significant one. The only negative note of significance is the general characterization of the customer in the EATM document as being airlines. This is further discussed in 4.3.1.2 below.

4.1.2 All the documents reference a short term, mid-term, and long term view of ATM systems. The long term is the most uncertain in all three for obvious reasons. It is highly recommended that an effort be made soon to harmonize the long term outlook in all three documents as they are updated in the coming years.

4.2 The three documents contain varying levels of specificity with the ICAO document taking the most global, macro level view of future systems. The EATM and RTCA document are appropriately more detailed in their respective description of the future ATM systems the authors envisioned.

4.3 A significant difference between the RTCA and EATM (and to some degree the ICAO) documents is the fact the RTCA document was written with a conscious and strong effort to not characterize the airspace system user as primarily, or at best case mostly, consisting of scheduled air carriers.

4.3.1.1 This is driven by the fact that general and business aviation in the United States represents tens of thousands more aircraft than the totality of the scheduled air carriers combined. Turbine powered aircraft alone flown in support of business aviation in the US still outnumber total scheduled air carrier fleets by several thousand.

4.3.1.2 The EATM document makes small acknowledgement of the presence of other than scheduled air carriers as a customer whose needs should be taken into account in designing the ATM system of the future.

4.3.1.3 The RTCA document does not use the “airline” versus “general aviation” methodology in describing those desired characteristics of the future ATM system. Rather, the RTCA document uses a different breakdown of the US customer into Civil, Military, and Space Transportation Users. Further the class of Civil users is further subdivided into those with Flight Operations Center (FOC) capability and those without.

4.3.1.3.1 The difference between FOC and non-FOC lies in the basis of the CDM process. The RTCA document acknowledges that System Wide Information Sharing (SWIM) is the best methodology of reaching the safety and capacity gains necessary to meet projections of traffic growth through 2025. Full use of SWIM and FOC models requires operators to have a dispatch or planning function commonly found in an Airline Operation Center. Since some non-airlines, fractional or management, in the US have adopted this approach to managing their fleets the generic “FOC” term is used by RTCA.

4.4 The matrix in Appendix D lists the major characteristics of all three documents that directly or indirectly support a future ATM system that would contribute to the growth of business aviation around the world.

5. ATM Evolution

> It is essential that the capabilities and system capacities offered by existing and future aircraft equipage, ATM infrastructure, and air traffic control systems be utilized to the maximum extent possible to deliver transitional benefits while the future system is being defined and developed.

5.1 The planning for implementation of various enabling technologies, procedures and practices, and infrastructure is under way in varying degrees in the ICAO regions. It is necessary that the acquisition and implementation be focused with a clear concept of how to integrate those elements into a coherent and seamless global ATM system. It is also essential that the capabilities of existing and future aircraft equipage, air traffic control systems and ATM infrastructure be utilized to the maximum extent possible to deliver transitional benefits while the future system is being defined and developed.

5.2 The global ATM system must be developed and organized to overcome the limitations of the current system, and to accommodate future growth, so as to offer the best possible service to all airspace users and to provide adequate economic benefits to the aviation community – effectively to meet the expectations listed above. The global ATM system must also be developed to ensure harmonization and synchronization of change, so that benefits are maximized.

5.3 It must be a goal of the ATM system that aircraft are able to equip with a minimum set of avionics which is usable everywhere. It is not acceptable to require one set of avionics within one region and a different set in other regions, each performing essentially the same functions. Moreover, if international operators improve their on-board capabilities to exploit ATM service improvements implemented in one State, the return on their investment will be enhanced if the same improvements are implemented in other States. Some service improvements cannot be implemented meaningfully in only one FIR. For example, to achieve the expected benefits, it is desirable that reduction in separation be implemented in all contiguous airspace through which a significant number of aircraft will travel – a so-called homogeneous traffic flow.

5.4 It must also be a goal of the ATM system that infrastructure and avionics no longer required to be removed from service.

Implementing the goals and strategies of global ATM

5.5 The primary goal of an integrated, global ATM system is to safely and effectively meet the expectations of the ATM community. The ATM system should enable aircraft operators to meet their desired business outcomes. For example, the system should allow operators to meet their schedules, to the extent possible, and adhere to their preferred flight profiles with minimum constraints and no compromise to safety, allow State aircraft to meet their national interest objectives safely and efficiently, and allow general aviation including business aviation to operate safely and in a way that doesn’t impact their business or personal objectives and have full access. The ATM community should also include military operations and missions including UAVs.

5.6 To accomplish the goal of an integrated, global ATM system safely and effectively meeting the expectations of the ATM community, existing and emerging infrastructure and capabilities – and any under-utilized capacity of the operating environment - must be fully exploited through international harmonization of ATM regulation, standards, procedures and practices.

5.7 From the aircraft operator’s point of view, it is desirable to equip aircraft operating domestically and internationally with a minimum set of avionics for universal application. Additionally, many of the expected service improvements cannot be meaningfully implemented by one State alone, but must be implemented in contiguous regions. Therefore, the ATM regional concept of providing ATM over expanded areas must be pursued.

Operational Improvements

5.8 In order to enhance collaboration and to enable a more expeditious approach to ATM evolution, potential Operational Improvements have been grouped into an ATM Transition Roadmap (See Chapter 6) with a relatively small number of logical groupings while at the same time sharpening the definitions of the individual Operational Improvements. In determining the grouping of operational improvements, the following criteria were used:

- A grouping covers a significant change to ATM operations;
- A grouping is ALWAYS oriented towards implementation;
- A grouping contains a consistent or logical set of interdependent Operational Improvements that are all expected to be implemented within the same timeframe;
- A grouping as a whole should bring a measurable and cost-effective benefit in performance (i.e. capacity, safety, environmental impact, cost efficiency); and
- A grouping must, of course, meet safety requirements given by the environment in which it will be implemented independent of the volume of traffic.

Short Term ATM Evolution

The short-term evolution involves the full deployment of a number of pragmatic measures, many of which have already been agreed or are in varying stages of implementation:

- Extending the use of the best practices;
- Better airspace organization, resource and people management;
- Increased use of existing aircraft interactive and self-contained capabilities;
- Implementation of existing standards for capacity and efficiency enhancement;
- Increased levels of automation support for pilots and air traffic management personnel where required; and
- Improving and preparing existing ground and airborne systems for further integration.

5.9 With the common long lead times for ATM and avionics systems changes, the first baseline period – that is implementation through the short term horizon - must build almost completely on current ATM capabilities and standards. In progressing the evolution of the ATM environment towards a harmonized system, a number of important foundations will have to be established in this first baseline.

5.10 In the area of airspace management the current system is often too rigid to allow maximum efficiency in activating the right airspace configuration at the right time. In the first baseline period there will be more dynamic management and use of the airspace based on a collaborative approach between civil and military authorities, service providers and users. Airspace will be designed to support dynamic demand and requested flight profiles. These developments will start at regional level and will subsequently reach a network wide implementation in the second baseline period.

5.11 At the same time there will be another important foundation being laid, particularly at airports, where CDM processes will be introduced on an increasing basis. However, for the purpose of tactical traffic flow management, first-come-first-served will always be retained as a tool for air traffic controllers to use in managing air traffic. This will allow minimal and precise flow and sequencing measures to be applied, higher predictability of schedules to be achieved, and retain the flexibility for non-scheduled operations such as business aviation.

5.12 Also at airports (airside) there will be safety and efficiency improvements in the ground movement of all vehicles when, as a result of Advanced Surface Movement Guidance and Control System (A-SMGCS) implementations (where required), improved airport surveillance tools, in combination with proper aerodrome control procedures, will allow for safe and efficient control of the ground movements, also in low visibility conditions and in darkness. Basic (passive) arrival management tools will also become more commonly used.

5.13 With air traffic levels growing and with the spreading of operations over more airports (particularly with operators executing emerging business/operating models using currently underused airfields) the environmental considerations of noise and gaseous emissions will need a clear and consistent policy. This will require harmonized standards for environmentally sustainable operations, and best practices to minimize the environmental impact.

5.14 While the current generation of ATC systems is still not ideally suited to easily integrate Decision Support Tools (DSTs) for air traffic control, there will be developments in this first baseline period to integrate a first set of tools primarily comprising support for conflict detection and flight path monitoring in those areas where automation is needed to support evolving ATM.

5.15 Airspace productivity is not only increased by providing the required system support to ATM staff, but also by making sure that the right capacity is available at the right moment. Besides timely anticipation on training needs for new service personnel this also means that staff rostering needs to become better adapted to traffic demand. This is expected to also have a positive effect on cost efficiency.

5.16 During this baseline period aircraft will incorporate a number of new technologies. These will include:

- basic air-ground data link communications capability;
- increased navigation performance based on application of GNSS and associated space-based ground-based, and/or aircraft-based augmentations; and
- Automatic Dependant Surveillance, both Contract (ADS-C) (also known as “Addressed” [ADS-A]), and the out portion of the Broadcast protocol (ADS-B-out) to enhance surveillance information.
    - ADS-C will be used primarily in oceanic and remote environments while 'ADS-B out' will be applied in domestic and remote applications where 1090 MHz ground stations can be used in lieu of more expensive Secondary Surveillance Radars. This will set the framework for reduced global dependence on radar where currently deployed, particularly secondary surveillance radar.

5.17 Where demand capacity balancing is required, it will be delivered with the increasing collaboration of ANSPs, all airspace users and airports to maximize the use of available capacity and progressively tend to managing capacity itself. CDM application will here also bring significant benefits, allowing all participants to be better informed of constraints and options.

5.18 Important safety related developments are the implementation, as described in ICAO Annex 6 Part I and II, of Airborne Collision Avoidance System (ACAS) II and additional safety nets like surface moving maps and similar situational awareness tools. These will also need coordinated development of ground-based safety nets (in particular Short Term Conflict Alert, Area Proximity Warning, Runway Incursion Alerting Systems and Minimum Safe Altitude Warning).

Medium Term ATM Evolution

The medium term evolution involves:

- Increased, integration of information systems;
- Improved information exchange between systems;
- Better use of the available capacity at airports;
- More accurate information about aircraft positions;
- Better computer support tools for pilots and air traffic management personnel;
- Better prediction of aircraft conflicts; and
- Pilots responsible for maintaining spacing applications in certain circumstances.

5.19 Necessarily the timing of the operational evolution will be less precise when trying to describe the operations further into the future. In this document the focus is however more on the sequential nature of groups of changes. Considering that several foundations have been laid in the first baseline, the evolution up to the second baseline will show relations between these foundations being strengthened and new improvements being built on top.

5.20 The various regional improvements in dynamic real-time management of the available airspace and routes will be integrated at a network level through a central network management function. This function will assess the coordinated civil and military demand and coordinate with the various area control centers and airports the most applicable configuration of sectors, routes and runways. Demand restrictions will only be applied where capacity cannot be sufficiently provided. Various sector activation scenarios will be defined for both the upper and lower airspace where required. This group of changes will improve the efficient use of resources while achieving a better network productivity.

5.21 At airports, in this medium-term period a local integration of arrival and departure management functions together with further A-SMGCS implementations, e.g. guidance and control functions to optimize the runway and taxiways utilization and achieve a safe and efficient ground processing of every aircraft. Aircraft wake vortices will be actively monitored and the resulting information may be used in optimizing minimum separation.

5.22 In order to further increase the sector capacity potential the medium-term will see controller tasks being supported by more advanced automation and some separation responsibilities being delegated to cockpit crews, subject to appropriate developments in capability. The advanced tools may provide some active advisories to controllers and will exchange data with other tools, locally and remote, in order to minimize the impact of disturbances while optimizing flexibility.

5.23 On board the aircraft the medium-term will see advances in data link support for exchange of information with ATM service systems. ADS-B with Cockpit Display of Traffic Information (CDTI) will be available to support some basic delegated tasks.

Long Term ATM Evolution – The ATM OPERATIONAL CONCEPT

The longer-term evolution will include:

- re-distributing tasks between people and machines and, where appropriate, between controllers and pilots, to help improve the levels of productivity;
- using integrated air and ground data communications in a number of air traffic control centers and at major airports; and
- advanced computer tools.

Evolution to the operational concept

5.25 The operational concept describes the components in a global sense. The end state described in this operational concept aims at global harmonization by the concept horizon of 2025. It is recognized that the end state of the operational concept will be reached through a set of evolutionary steps. However, the end state will be a transformed operational concept with improved level of productivity where certain tasks have been re-distributed between people and machines and as appropriate between controllers and pilots.

5.26 This allows States, regions and homogeneous areas to plan the significant investments that will need to be made, and the timeframe for those investments, on a partnership basis, and within a framework of safety and business case. The ATM operational concept also provides the basis from which the ATM operational requirements, objectives and benefits will be derived, thereby providing the foundation for the development of regional and national ATM implementation plans.

Scalability and adaptability

5.27 The operational concept is adaptable to the operational environment of all States and regions, and is scalable to meet their specific needs. This recognizes the fact that while there are urgent requirements to implement ATM changes to meet a range of needs, *inter alia*, the growing traffic demands in certain areas, or a lack of infrastructure in other areas, the appropriate solutions may differ. In many areas, simple solutions based on regional harmonization or cooperation across homogeneous areas may provide satisfactory short or medium term responses to the requirements of this concept document, while in other areas, sophisticated ATM systems may be required.

Different regional expectations

5.28 The expectations enunciated within any one particular region will be different to an adjacent or distant region, in the initial stages of evolution to the ATM system described in this operational concept. The concept allows that different emphasis can be placed on the various concept components to derive identified operational benefits. However, any such emphasis must still recognize that each component is a standard and uniformly understood “building block” that facilitates the movement of aircraft through regions with little or no change to equipment or procedures. Ultimately, the goal is to achieve global harmonization and interoperability.

Regional coordination

5.29 Recognizing that not all States or regions can move immediately to the ATM system described in this concept, the operational concept contains details on an expected planning and evolutionary process, within the ICAO framework. The implementation of the concept is provided for by strategic plans, *inter alia,* the Global Air Navigation Plan for CNS/ATM Systems, regional plans and state implementation plans, which also describe the progressive intermediate steps toward that goal. The plans of all States need to be aligned to ensure, to the greatest extent possible, that solutions are internationally harmonized and integrated, and do not unnecessarily impose multiple equipment carriage requirements in the air components of the ATM system, or multiple systems on the ground.

Introduction to the ATM concept components

5.30 The ATM system will be based on the provision of integrated services. However, to better describe how these services will be delivered, seven concept components, together with their expected key conceptual changes, are described in capsule form below, and in more detail in Sections 2.2 to 2.8 of the ICAO ATM Operational Concept Document (OCD). In addition to the seven concept components, Section 2.9 of the OCD, on information services, describes the exchange and management of information used by the different processes and services. The ATM system needs to be disaggregated to understand the sometimes-complex interrelationships between its components. The ATM system cannot, however, function without any of its components, which must be integrated. The separate components form one system.

Airspace Organization and Management (AOM)

5.31 Airspace organization will establish airspace structures in order to accommodate the different types of air activity, volume of traffic, and differing levels of service. Airspace management is the process by which the airspace options are selected and applied to meet the needs of the ATM community. Key conceptual changes:

- all airspace will be the concern of ATM and will be a useable resource;
- airspace management will be dynamic and flexible;
- any restriction on the use of any particular volume of airspace will be considered transitory; and
- all airspace will be managed flexibly. Airspace boundaries will be adjusted to particular traffic flows and should not be constrained by national or facility boundaries.

Aerodrome Operations (AO)

5.32 As an integral part of the ATM system, the aerodrome must provide the needed ground infrastructure including, *inter alia*, lighting, taxiways, runway and runway exits, precise surface guidance to improve safety and to maximize aerodrome capacity in all weather conditions. The ATM system will enable the efficient use of the capacity of the aerodrome airside infrastructure. Key conceptual changes:

- runway occupancy time will be reduced;
- the ability to safely maneuver in all weather conditions while maintaining capacity;
- precise surface guidance to and from a runway will be required in all conditions; and
- the position (to an appropriate level of accuracy) and intent of all vehicles and aircraft operating on the maneuvering and movement areas will be known and available to the appropriate ATM community members.

Demand and Capacity Balancing (DCB)

5.33 Demand and capacity balancing will strategically evaluate system-wide traffic flows and aerodrome capacities to allow the airspace users to determine when, where and how they operate, while mitigating conflicting needs for airspace and aerodrome capacity. This collaborative process will allow for the efficient management of the air traffic flow through the use of information on system-wide air traffic flow, weather and assets. Key conceptual changes:

- through CDM at the strategic stage, assets will be optimized to maximize throughput thus providing a basis for predictable allocation and scheduling;
- through CDM, when possible, at the pre-tactical stage, adjustments will be made to assets, resource allocations, projected trajectories, airspace organization, and allocation of entry/exit times for aerodromes and airspace volumes to mitigate any imbalance; and
- at the tactical stage, actions will include dynamic adjustments to the organization of airspace to balance capacity; dynamic changes to the entry/exit times for aerodromes and airspace volumes; and adjustments to the schedule by the users.

Traffic Synchronization (TS)

5.34 Traffic synchronization refers to the tactical establishment and maintenance of a safe, orderly and efficient flow of air traffic. Key conceptual changes:

- there will be dynamic 4-D trajectory control and negotiated conflict-free trajectories;
- chokepoints will be eliminated; and
- optimization of traffic sequencing will achieve maximization of runway throughput without prohibiting access to any member of the user community.

Airspace User Operations (AUO)

5.35 Airspace user operations refer to the ATM-related aspect of flight operations. Key conceptual changes:

- accommodation of mixed capabilities and worldwide implementation needs will be addressed to enhance safety and efficiency;
- relevant ATM data will be fused for an airspace user's general, tactical and strategic situational awareness and conflict management;
- relevant airspace user operational information will be made available to the ATM system;
- individual aircraft performance, flight conditions, and available ATM resources will allow dynamically-optimized 4-D trajectory planning;
- coordination will ensure that aircraft and airspace user system design impacts on ATM are taken into account in a timely manner; and
- aircraft should be designed with the ATM system as a key consideration.

Conflict Management (CM)

5.36 Conflict management will consist of three layers: strategic conflict management through airspace organization and management, demand and capacity balancing and traffic synchronization; separation provision; and collision avoidance.

5.37 Conflict management limits, to an acceptable level, the risk of collision between aircraft and hazards. Hazards that an aircraft will be separated from are: another aircraft, terrain and obstacles, weather, wake turbulence, incompatible airspace activity and when the aircraft is on the ground, surface vehicles and other obstructions on apron and maneuvering area. Key conceptual changes:

- strategic conflict management will reduce the need for separation provision to a designed level;
- the ATM system will minimize restrictions to user operations; therefore, the pre-determined separator will be the airspace user, unless safety or ATM system design requires a separation provision service;
- the role of separator may be delegated, but such delegations will be temporary;
- in the development of separation modes, separation provision intervention capability must be considered;
- the conflict horizon will be extended as far as procedures and information permit; and
- collision avoidance systems are part of ATM safety management, but are not included in determining the calculated level of safety required for separation provision.

ATM Service Delivery Management (SDM)

5.38 ATM service delivery management will operate seamlessly from block-to-block for all phases of flight and across all service providers. The ATM service delivery management component will address the balance and consolidation of the decisions of the various other processes/services, as well as the time horizon at which, and the conditions under which these decisions are made. Flight trajectories, intent and agreements will be important components to delivering a balance of decisions. Key conceptual changes:

- services to be delivered by the ATM service delivery management component will be established on an as-required basis subject to ATM system design. Where services are established they will be provided on an on-request basis;
- ATM system design will be determined by CDM and system-wide safety and business cases;
- services will be delivered by the ATM service delivery management component through CDM, balance and optimize user-requested trajectories to achieve the ATM community’s expectation; and
- management by trajectory will involve the development of an agreement that extends through all the physical phases of the flight.

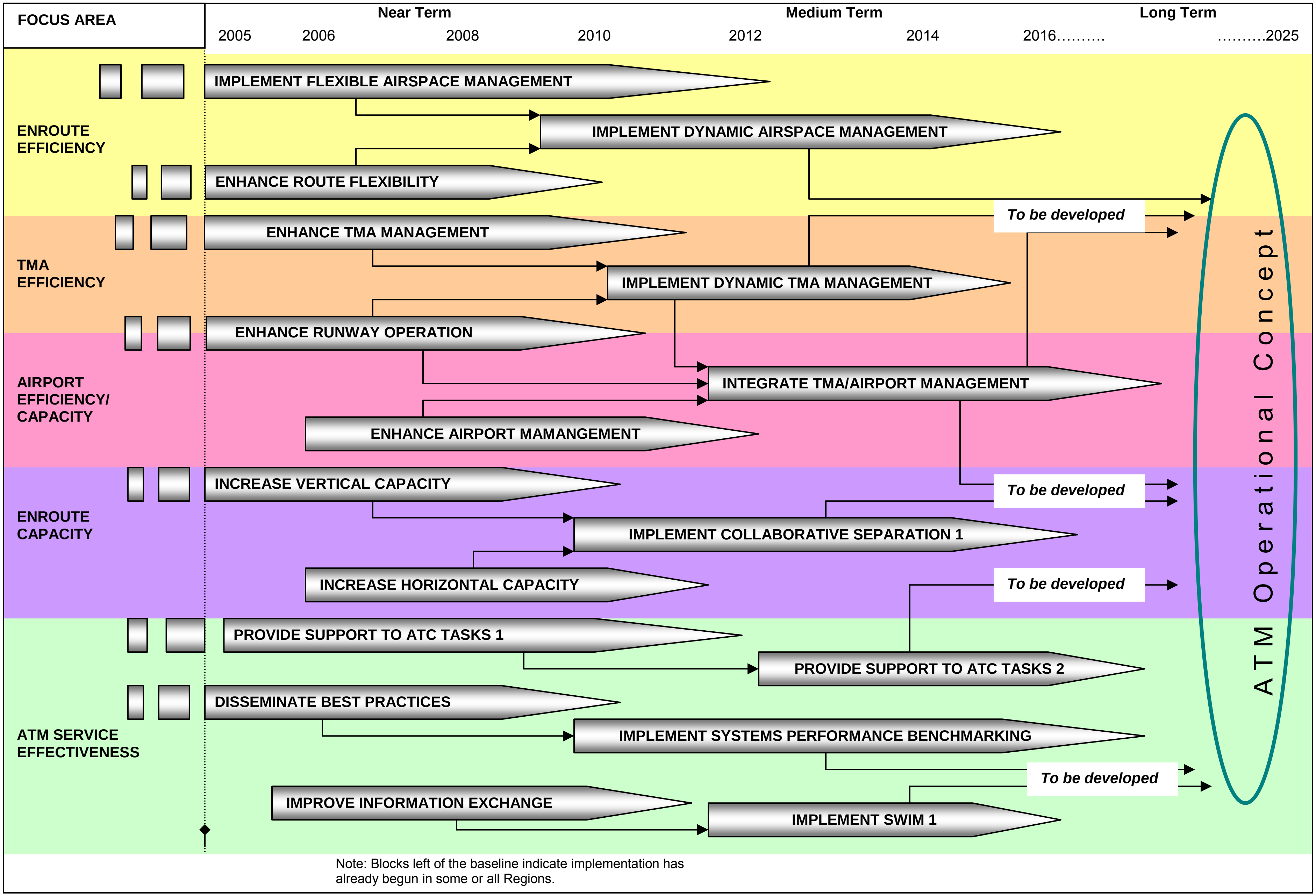
6. The ATM Transition Roadmap

6.1 The ATM Transition Roadmap lays out an overall thrust or set of objectives along the ATM evolution path. This map shows initiatives in a short to medium term timeframe. Within this document, short-term is identified as a five to seven year horizon commencing with a base date of 1 January 2005. Medium term is identified as a similar horizon commencing in the 2010 timeframe. Objectives and deliverables in the longer-term 15-20 year horizon are being addressed by the ATMCP. The ATM enhancements derived from this roadmap are fundamentally aligned with the future direction enunciated in the ATM Operational Concept.

6.2 The map is shown at two levels. The first level (overleaf) shows the main performance benefit streams against the capacity and efficiency enhancement areas of enroute, terminal area and airports. There are some linkages shown – but these will need to be detailed further. The benefit streams are shown through the short and medium term. The second level maps show individual performance enhancing activities, which may be either a single activity, or a series of linked activities through a particular time horizon. Some blocks are shown starting prior to the baseline date of January 2005. These activities have already begun in various parts of the world.

6.2.1 There are many ways to present a transition map - and it would be impossible to address all aspects of ATM transition on the same high-level presentation. A deliberate choice has been made here to focus on one perspective, which is expected to be meaningful for the widest possible audience. Regions and States are, however, encouraged to develop complementary presentations that better fit other perspectives or areas of specific interest.

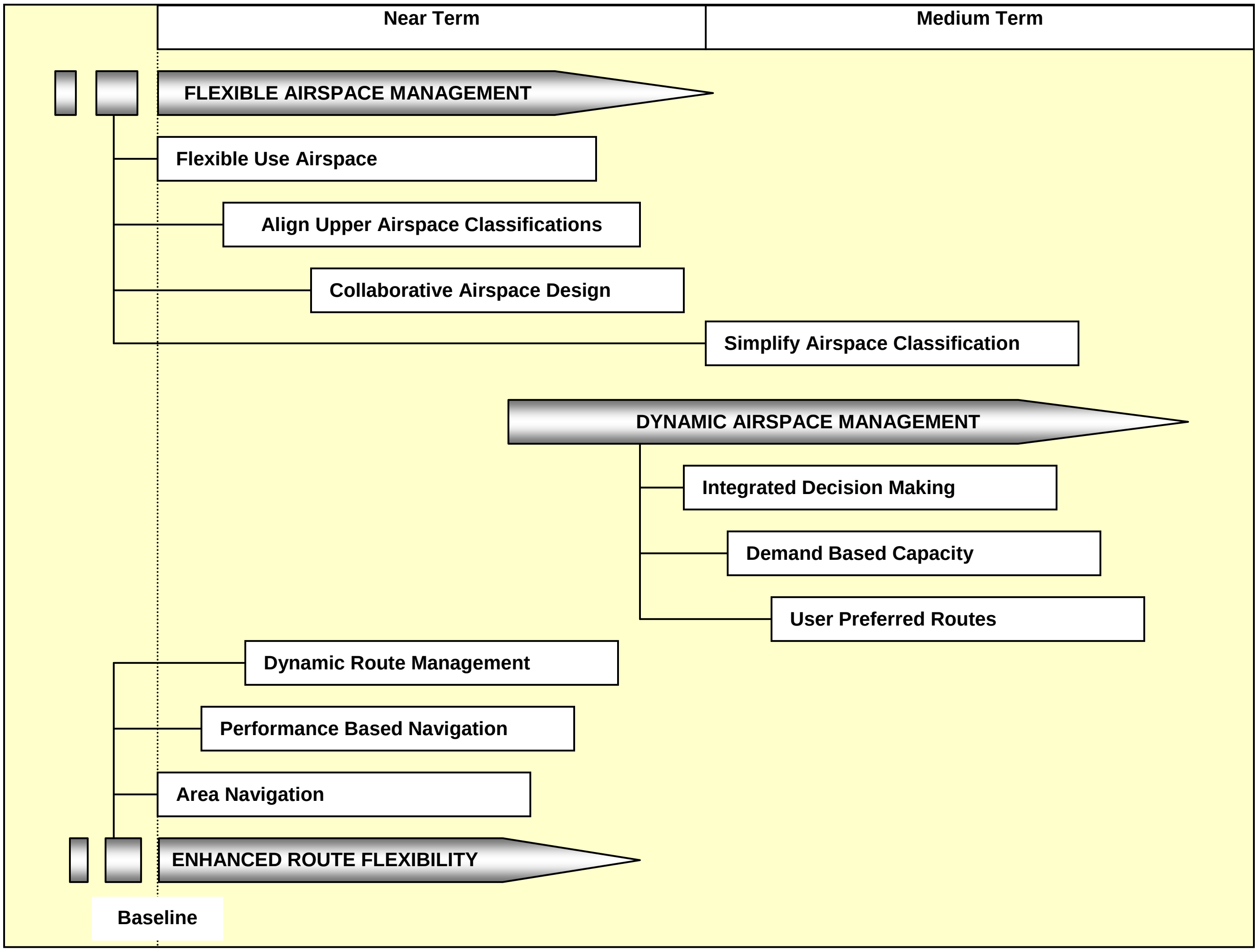
ATM TRANSITION ROADMAP



Note: Blocks left of the baseline indicate implementation has already begun in some or all Regions.

ENHANCE RUNWAY OPERATIONS

6.3 ENROUTE EFFICIENCY



6.3.1 General principles

6.3.1.1 The ATM Operational Concept states that "...all airspace should be considered a useable resource, and any restrictions on access to airspace (i.e., Prohibited or Restricted Airspace) should be appropriately justified, and considered as transitory, and not permanent".

6.3.1.2 In many areas of the world, restricted airspace is created for activities notionally deemed as incompatible with the safe operation of civil flights. These may include military flying training, ground to air firing activity etc. In most cases, such activity is transient – i.e., operates on either an irregular basis, or on a known schedule – yet the airspace is closed 24 hours a day, 7 days a week. In many cases, safe access to this airspace would result in substantial benefit to non-military operators in terms of time and fuel costs.

6.3.1.3 In many areas of the world, ATC/ATS services are based on rostered hours of coverage, resulting in excess staff being on duty during times of low traffic densities. In some cases, sectors are kept open to utilize those staff, even though they have little or no workload. Such staffing results in high service costs (both staff and system maintenance) and subsequent high charges to operators.

6.3.1.4 In certain areas of the world, the present airspace delineation practice results in excessively small control areas, which are unrelated to the route pattern. Such areas are often extremely small and unsuited to the needs of aircraft operations, because aircraft transiting them must communicate with and obtain clearances from the ATC Centers of each area concerned. In practice, on occasions an aircraft may pass into the next area before it has received a clearance. The present practice necessitates complex inter-facility communications and data transfer systems, which, in many cases, are not implemented.

6.3.2 Implement Flexible Use Airspace

6.3.2.1 The Flexible Use of Airspace (FUA) concept requires the implementation of effective civil/military co-ordination through enhanced and appropriate enabling procedures, processes and tools (that may yet need to be developed). Such co-ordination will be based on transparency of airspace user requirements, alignment of airspace and capacity management processes closer to the time of operations, include all ATM community members and be "system-supported" with shared information.

6.3.2.2 FUA is based on the fundamental principle that airspace should not be designated as purely civil or military, but rather be considered as a continuum in which all user requirements should be accommodated to the greatest possible extent. In most States, FUA is barely used, but is predicted to have significant potential to benefit ATM if widely implemented. It should therefore be the desire of both civil and military authorities, that FUA be implemented.

6.3.2.3 The introduction of FUA will create the ability of civilian aircraft to be managed by an ATM system able to recognize and attempt to achieve the user preferred trajectory whether that trajectory is in accordance with published air routes or not. In the case of military aircraft (including UAVs) the introduction of FUA will enable better access of restricted airspace by segmentation using FUA and simultaneously provide a 'roam free' capability for military aircraft in airspace shared with other ATM service providers. Effectively, the concept of FUA would see the removal of the need for large tracts of permanent or transient restricted airspace or special use airspace.

6.3.2.4 FUA should be used where Industry has identified that regular and sustainable economic benefit can be achieved, and should be introduced and maintained so as to optimize the efficient use of controlled and restricted (or equivalent) airspace. A priority list of areas where FUA can provide the most benefit and the times of FUA application should be developed and utilized. Civil and Military ATC units should adhere to agreed FUA optimization areas and times.

6.3.2.5 Whenever possible, airspace users will be given access to airspace based on the FUA concept, rather than restricting ATM based on strict segregation of airspace. FUA will accommodate the peacetime operation of State aircraft in accordance with State policy and priority. Such policy and priority should not unreasonably restrict the operation of civil aircraft.

6.3.2.6 Where there is a reasonable requirement for individual airspace users to “block” airspace of certain dimensions, this should be accommodated on a transient basis – that is, any restriction on access to airspace will be temporary, and airspace will be released for general access immediately after the operation requiring the restriction is complete.

6.3.2.7 As FUA is a new concept in most States, FUA would be subject to staged introduction, based upon the highest need areas having the most priority for FUA establishment and use. Close coordination among all airspace managers, particularly between civilian and military, is a fundamental requisite of the flexible use of airspace. ATM and infrastructure systems must support this function by enhancing capabilities of information exchange and real time monitoring of airspace status.

6.3.2.8 Regular consultation should be undertaken with Industry to ensure that FUA is promoted as a means of attaining economic flight and efficient use of airspace. This will also include the regular review of FUA to ensure harmonization with air routes, both fixed and User Preferred Routes (UPR). The key elements of FUA are:

- Predefined military use airspace scenarios, designed with flexibility in mind to satisfy current and future regional/national mixture and task of forces. Such airspace structures would form an integral part of the airspace infrastructure.
- Coordination of airspace management cell and capacity management functions at national, sub-regional or regional level, enabling a comprehensive evaluation of demand, available capacity and potential capacity shortfalls and airspace configuration options to resolve.
- Airspace data repository to provide accurate information on airspace and route availability updated in real-time and in accordance with ATM airspace-related decisions, including information on routes, ATM units, and area relationships and associated scenarios.
- Route activation/military airspace allocation made in a highly dynamic manner within a CDM process reflecting the different stakeholders’ roles and responsibilities, taking into account civil traffic flows and the military training and operational profile as required. In this context routes would be plannable options, unless de-activated, while pre-defined military use airspace would not be active until allocated.

6.3.3 Align Upper Airspace Classifications

6.3.3.1 In order to facilitate the introduction or better utilization of data link communications, improved flight plan processing systems, and advanced airspace management co-ordination tools and message exchange capabilities, leading to progressively more flexible and dynamic management of airspace, it is necessary to ensure that service levels in upper airspace are aligned.

6.3.3.2 It is likely that greater delegation of ATC responsibilities across Flight Information Regions (FIRs) will be used to address particular traffic confluence or congestion problems at particular times – particularly as systems become more integrated. In the short to medium term, where traffic densities permit, there will be an evolutionary change from fixed airspace divisions to flexible airspace allocation.

6.3.3.3 The aim is to move to an entirely flexible airspace structure in the medium term, whereby airspace sector boundaries are adjusted to particular traffic flows and peaks in demand in real-time, and are not constrained by National boundaries. The harmonization of upper airspace classifications is a pre-requisite to this evolution.

6.3.3.4 The implementation of RVSM is progressively aligning all airspace above FL290 as Class A airspace. States should consider further standardizing upper airspace, possibly that airspace above FL245, as Class A airspace**.** In addition, European States are pursuing the progressive implementation of RVSM as of November 2003 for Class C airspace above FL195. In this connection, it also noted that restrictions on Visual Flight Rules (VFR) operations would be implemented simultaneously.

6.3.4 Simplify the Airspace Classification System

6.3.4.1 Airspace classification must be transparent and as simple as possible for users, while permitting unambiguous rules for ATS service provision, and describing simply the flight planning, communication and minimum equipment requirements.

6.3.4.2 In the short term, air traffic services provided in various airspace volumes should be based specifically on the ICAO airspace classification system as defined in Annex 11 (i.e., Class A to G), and those classifications should be made based on a structured safety assessment. Notwithstanding, air transport and most business aviation operations should be contained within airspace within which positive air traffic control services are provided to all aircraft (i.e., Class A, B, C or D).

6.3.4.3 In the medium term, the current ICAO classification system will be reviewed and a more service and performance oriented delineation applied. This should result in a reduction of the current 7 airspace classifications, while allowing individual aircraft capabilities and performance to be recognized in the provision of ATM services.

6.3.5 Collaborative Airspace Design

6.3.5.1 Current airspace and air route design practices are still often based on the overflight of radio navigation aids, and basic air traffic control processes. A large and growing percentage of the aircraft fleet operating globally has GNSS-based area navigation (RNAV) capability. Consequently, there is a rapidly decreasing need for air routes to be designed around the use of ground-based navigation aid infrastructure – particularly in the enroute domain. This is also increasingly true in terminal area - airspace. Other emerging developments – such as CDM, cooperative ATM and advanced data link capability – will offer further design options. In the future, RNAV equipped aircraft should have a significantly enhanced capability to achieve sequencing requirements (particularly through the use of the Required Time of Arrival function within the Flight Management System) without the need for ATC intervention. There are currently many aircraft equipped with RTA capable FMS and more will be equipped in the future.

6.3.5.2 A key tenet of the ICAO Operational Concept is that all airspace is a resource that requires balanced access to all airspace users. Many States and Regions have begun re-design programs aimed at improving airspace management. In many cases, and in the absence of global guidance material, this re-design is being done independent of a uniform and standardized design process.

6.3.5.3 In designing and implementing airspace changes, account needs to be taken of the fleet capabilities among airspace users within a given operating environment. Collaboration with airspace users can also identify procedures and/or solutions that make use of those capabilities.

6.3.6 Area Navigation

6.3.6.1 Area navigation pertains to method(s) of navigation that enables aircraft to fly on any desired flight path within the coverage of referenced navigation aids (NAVAIDS) or within the limits of the capability of self-contained systems, or a combination of these capabilities. Routes and procedures using RNAV are not restricted to the location of ground-based NAVAIDS.

6.3.7 Performance Based Navigation

6.3.7.1 A significant number of aircraft are RNAV and RNP capable. This capability should be exploited to develop more efficient routes that are not directly tied to ground based navigation aids. A significant and growing number of aircraft include the GNSS positioning service in their navigation systems. This navigation method supports linear (constant error) navigation performance, which provides for a natural transition into RNP with containment (performance bounding). Linear performances measures but without the containment features of RNP can still provide significant opportunities for improving airspace usage and operational efficiencies.

6.3.7.2 The initial concept of RNP established by ICAO was a navigation accuracy standard based on 95% probability of remaining in the designated RNP value for the airspace. Modern aircraft systems have been designed with this concept expanded to add the concept of containment. Containment adds significant additional confidence that the overall navigation performance is contained to a factor of the RNP value (e.g., 2 times) to a high probability. The containment concept can be used to classify and separate airspace more efficiently and should be implemented as soon as practical when aircraft equipage will support and on a non-exclusionary basis.

6.3.7.3 This equates to recognition of an “actual navigation performance” of the aircraft. Recognition of that performance will allow reduction in horizontal spacing with regard to obstacles, terrain, ground, or other hazards, with greater confidence.

An example of capability-based navigation is the application of PRNAV procedures in Europe.

6.3.8 Dynamic Route Management

6.3.8.1 Increasingly, aircraft capabilities both reduce the dependency on pre-defined route structures, and require access to dynamic trajectories that take advantage of actual rather than forecast meteorological conditions. Techniques that facilitate dynamic route management include Dynamic Airborne Rerouting Programs (DARP), Random Routing, and eventually User Preferred Routes.

6.3.8.2 DARP is a technique used in the S. Pacific FANS airspace. In this application, DARP enables in-flight re-planning of tracks, based on updated forecast weather conditions, allowing aircraft to optimize their trajectories in flight. DARP is an integrated air and ground capability involving ground automation and airborne system elements.

6.3.8.3 Random Routing strategically or pre-tactically defines areas within which fixed routes are not designated, and within which aircraft determine an appropriate track from an entry point to an exit point. This may be determined prior to flight, or in-flight.

6.3.9 Integrated Decision Making

6.3.9.1 Integrated decision-making is an extension of the principles of flexible use of airspace to include airspace users in flight in decision making on access or otherwise to airspace volumes. This may include tactical assessment of the use of reserved airspace, compatibility of civil and military operations, required transit times, aircraft navigation capabilities and so on.

6.3.10 Demand Based Capacity

6.3.10.1 Demand-based capacity involves the implementation of a more dynamic management of airspace, based on a collaborative approach between civil and military authorities to design and activate airspace and routes as required by demand. These developments should start at regional level and subsequently reach a network wide implementation through the medium term.

6.3.10.2 Annual ATC sector productivity should also increase, by making sure that the right sector capacity is available at the right moment. This may have implications on timely anticipation of training needs for new controllers and on the adaptation of staff rostering to traffic demand. It will also require close cooperation with airspace users to provide appropriate levels of predictability.

6.3.10.3 Expected benefits will include flight efficiency improvements due to minimization of special use airspace impact and optimized airspace design, and a higher annual productivity with same resources, which is also expressed in a cost efficiency improvement.

6.3.10.4 Delineation of airspace within which air traffic management services are to be provided (e.g., sectorization) should be related to the nature of the route structure or traffic flows, and not to national boundaries or current service provision boundaries. High priority must be given to civil-military cooperation and creation of efficient and effective functional airspace blocks.

6.3.10.5 The number of ATS service divisions (sectors, etc) should be reduced to the minimum required for the provision of a safe, orderly and expeditious flow of air traffic. Where service divisions are created for specific traffic peaks, they should be consolidated as quickly as possible after the need for their creation has passed.

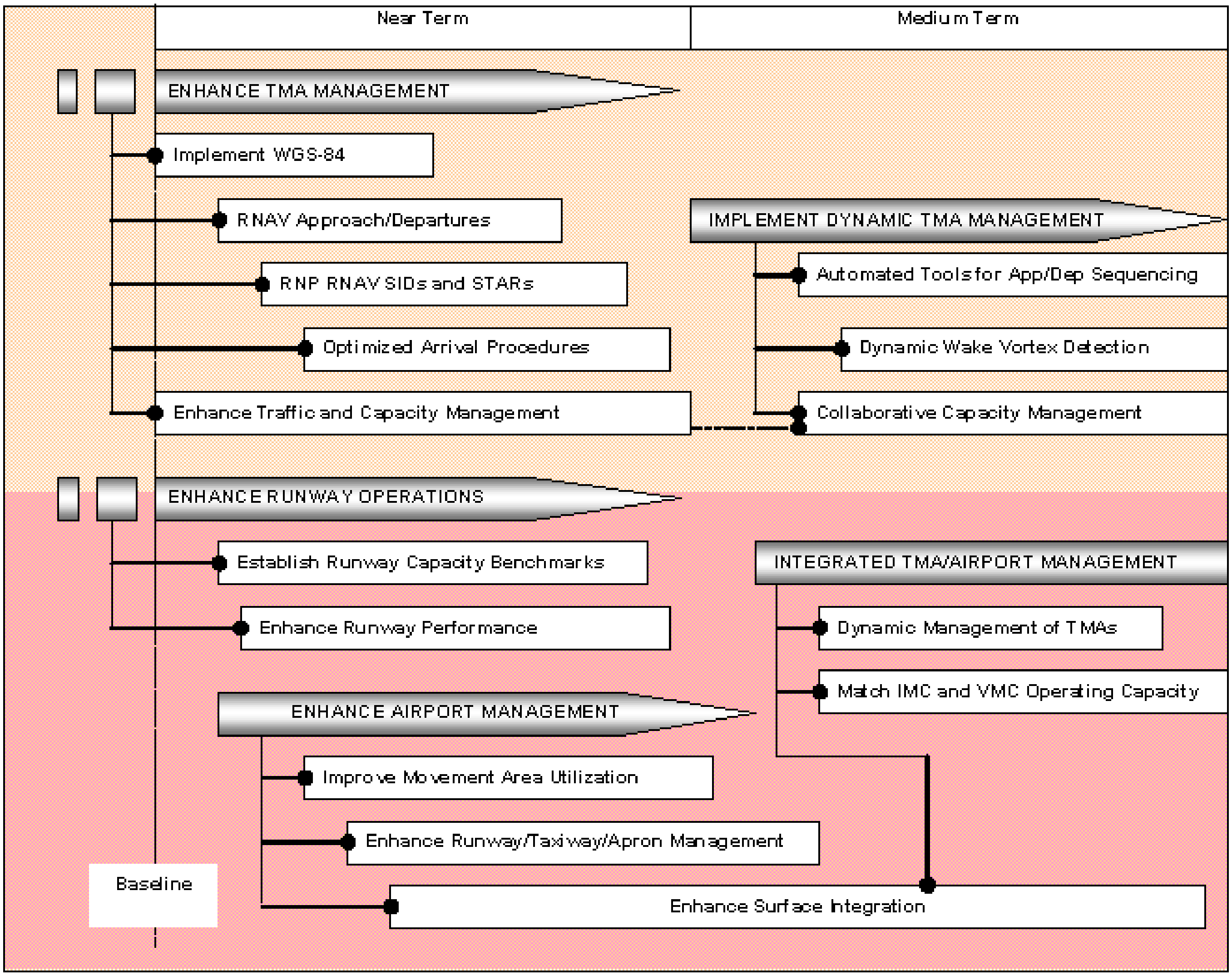
6.3.10.6 The potential of current and emerging enabling technologies (e.g., advanced data link, enhanced surveillance) should be fully exploited to further reduce airspace delineation.

6.3.11 User Preferred Routes

6.3.11.1 User Preferred Routes (UPR) make use of the capability of aircraft operators to determine optimum tracks, based on a range of flight parameters, and generally pre-flight. Except where required for control purposes, tracks are not fixed to pre-determined routes or waypoints – however, the trajectory is made available to air traffic management, and can be displayed to air traffic management staff for the provision of normal air traffic services.

6.3.11.2 Generally, UPRs make allowance for the static requirements or limitations of the air traffic management system, and flights will be planned and flown at standard flight levels, or over predetermined entry and exit points, to facilitate air traffic management requirements. UPR is a pre-cursor to User Preferred Trajectory.

6.4 TMA/AIRPORT EFFICIENCY/CAPACITY



6.4.1 General principles

6.4.1.1 The Terminal Area is defined as that portion of the airspace within the proximity of a controlled aerodrome within which arriving and departing aircraft are managed to provide separation, separation assurance, appropriate arrival spacing, appropriate departure spacing and final approach sequencing.

6.4.1.2 Terminal area design (and/or re-design) must be implemented uniformly across all terminal control areas within a State or Region, must provide for user and system benefits, and must target minimization of pilot/controller communications and optimization of pilot and controller workload.

6.4.1.3 Terminal Area arrival acceptance rates must be based tactically on a CDM process involving tower, TMA and en-route feeder sectors, and strategically involving airspace users, to ensure optimum traffic handling across the entire flight.

6.4.1.4 Except where specifically requested by airspace users or for specific noise abatement reasons, and after CDM, arriving traffic should have profile priority over departing traffic - that is, priority should be given to the use of continuous descent approaches for environmental and operational efficiency reasons.

6.4.2 Complete the Implementation of the WGS-84 Geodetic Reference System

6.4.2.1 Fundamental to the implementation of GNSS is the use of a common geographical reference system. ICAO adopted WGS-84 Geodetic Reference System as that datum, and many States have implemented, or are implementing the system. Failure to implement, or a decision to use an alternative reference system will necessarily create a seam in ATM service, and will delay the realization of GNSS benefits.

6.4.2.2 Completion of the implementation of the WGS-84 Geodetic Reference System is a pre-requisite for a number of ATM enhancements, and must be completed as a matter of urgency.

6.4.3 RNAV Arrival/Departures / RNP RNAV SIDs and STARs

6.4.3.1 Arrival and departure procedures should provide a seamless flight path between an airport and the appropriate ATS route structure or vice versa. The use of standard routes (generally via SIDs/STARs) is encouraged so as to maximize system capacity and predictability, ameliorate environmental impact, reduce fuel consumption, and to reduce ATS coordination.

6.4.3.2 Standard Instrument Departures (SIDs) are pre-planned and promulgated instrument departure routes. The departure route links the aerodrome or a specified runway with a specified significant point, normally on a designated air-route, at which the en-route phase of flight commences.

6.4.3.3 Standard Arrival Routes (STARs) are pre-planned and charted IFR arrival routes which link the en-route airways system to a fix at or near the destination aerodrome. They facilitate consistent and predictable arrival and approach procedures. When linked to an instrument approach procedure (and consequently a runway end) they allow FMS equipped aircraft to fly a predictable horizontal and vertical profile from top of descent to the runway.

6.4.3.4 SIDs and STARs should always be designed to exploit aircraft Flight Management System (FMS) and RNAV capabilities.

6.4.3.5 Tailored Arrival Procedures (TAP) are a dynamic application of STAR principles, utilizing aircraft and ground system capabilities to provide optimum trajectories to appropriately equipped aircraft. It is expected that TAP will become available through the medium term.

6.4.3.6 SID's and/or STARs may not be suitable for all aerodromes. Where required, SIDs and STARs will be designed to aid:

a. The efficient transition of aircraft from the departure end of the runway to enroute flight.
b. The efficient transition of aircraft from enroute flight to a stabilized approach to the runway

c. The segregation of departing traffic from arriving traffic to provide safe aircraft spacing;
d. Minimization of conflicts between departing and arriving flight paths;
e. The maintaining of obstacle clearance requirements;
f. The meeting of environmental requirements including noise abatement; and
g. Provision of a predictable flight trajectory compatible with aircraft RNAV systems.

6.4.3.7 Significant operational benefits can be realized by applying RNP capabilities in the Terminal Area.

6.4.4 Optimized Arrival Procedures

6.4.4.1 In recent years there has been a global desire to develop flight procedures that provide the most efficient trajectory during an aircraft's approach to the destination aerodrome. This is not simply an "idle power" approach, but is fundamentally an "uninterrupted flight trajectory from top of descent until the aircraft is stabilized for landing". For the purposes of design work in this planning period and beyond, it may be necessary for some States to operate specific phases:

- A Continuous Descent Arrival (CDARR) is an unimpeded (and consequently low thrust engine powered) vertical descent profile from an aircraft's commencement of descent until established on the Continuous Descent Approach (CDAPP);

- A Continuous Descent Approach (CDAPP) is an unimpeded (and consequently low thrust engine powered) vertical descent profile from an appropriate intermediate altitude above the aerodrome elevation and within an appropriate distance from the landing runway threshold until the aircraft is configured for landing.

- A Continuous Descent Final Approach (CDFA) is a descent from a final approach fix to landing which in conducted in a continuous descent in a stabilized manner. A guided path to every runway end should be the objective with other CDFA methods used if flight path guidance is not available.

6.4.4.2 These arrival and initial approach phases recognize the constraints in terminal areas produced by the need to facilitate departing traffic through arrival paths. Aircraft energy management constraints need to be considered in flight path development. Implementation of RNP capabilities would provide more lateral paths to accommodate unrestricted climbs and Continuous Descent Arrival/Approach (CDA) procedures.

6.4.4.3 The design of en-route and arrival air routes and associated procedures should facilitate the routine use of CDA procedures. Such procedures should be designed to allow idle-power or system optimum trajectories from top of descent to a point on a runway aligned precision approach. Similarly, the design of departure procedures should facilitate the routine use of Unrestricted Climb procedures. Where there is a conflict between this requirement and that of CDA, CDA should have priority.

6.4.5 Enhance Traffic and Capacity Management

6.4.5.1 The term Traffic and Capacity Management is used to describe any activity concerned with the organisation and handling of the flow of air traffic in such a way that, while ensuring the safe, orderly and expeditious flight for individual aircraft, the totality of the traffic handled at any given time or in any given airspace or airport is compatible with the capacity of the ATM system. Such a service will normally be implemented for airspace and airports where traffic demand at times exceeds the defined ATM capacity. There are periods when existing ATM capacity, including Airport capacity, is not sufficient to meet user demand and delays are imposed on the ground and in the air. Delay is the most visible symptom of capacity shortfall. Optimizing efficiency, and reducing capacity "bottlenecks", is the first step in reducing delays.

6.4.5.2 Future Traffic Management requirements indicate a need to move towards a more sophisticated, adaptive and dynamic process that can operate to finer capacity and time limits. There needs to be a progressive emphasis on the efficient and collaborative management of resources and capacities at airports, in terminal areas and in en-route sectors, so as to meet – rather than limit - demand. The overriding goal is to maximize the capacity provided to airspace users while maintaining appropriate levels of safety.

6.4.5.3 Traffic and Capacity Management should meet the following objectives:

a. assist safe operations by protecting the ATM system from traffic overload, and providing a smooth and efficient flow of traffic;
b. minimize the costs incurred by operators arising from the finite capacity of the ATM system and airport facilities;
c. improve Capacity Management and enhance efficiency wherever possible by concentrating on changes to airspace organization, procedures, human resource management and environment;
d. expand Tactical and Strategic Flow Management capabilities to minimize delays and holding at major airports; and
e. fully exploit the potential of existing and emerging ATM-related enabling technologies.

6.4.5.4 Predictability is essential to building and maintaining flight schedules. Variance in flight times disrupts schedules. The Traffic and Capacity Management system must provide predictability for operators and reduce ATM-related variations in chock-to-chock transit times.

6.4.5.5 The amount of delay experienced is a fundamental measure of capacity shortfall. An aircraft is considered to be subject to delay when its planned flight time is increased because of Air Traffic Management reasons. Delay must be routinely assessed to measure the ability of particular ATM service providers to match capacity and demand.

6.4.5.6 ATM Units and airport operators must explore the use of multiple runways (where available) to optimize capacity during peak periods. Where arrival and departure rates are set for airports and associated runway configurations, they should be established on the basis of stakeholder consultation. ATM units must continually measure the performance of, and report against, those rates.

6.4.5.7 In the event that traffic demand regularly exceeds capacity, resulting in continuing and frequent traffic delays, or it becomes apparent that forecast traffic demand will exceed capacity values, the appropriate ATM Units, in consultation with industry, should consider:

a. Implementing steps aimed at maximizing the use of the existing system capacity; and
b. Developing plans to increase capacity to meet the actual or forecast demand. Any such planning to increase capacity must be undertaken in a structured and collaborative manner.

6.4.5.8 It should be noted that increasing capacity may not be a viable option within system constraints such as cost, environment, national security, and so on.

6.4.6 Establish Runway Capacity Benchmarks

6.4.6.1 Capacity benchmarks are usually defined as the maximum number of flights an airport can routinely handle in an hour for above Category I weather minimum. These benchmarks are estimates of a complex quantity that varies widely with runway configurations and the mix of aircraft types. The maximum throughput associated with the capacity benchmark are significantly reduced with adverse weather conditions, inadequate radar equipment, less than optimum rules and procedures and inadequate Rapid Exit Taxiways (RETs) for arrivals or sequencing taxiways for departures. Capacity benchmarks assume there are no constraints in the en route system or the airport terminal area. They are useful for broad policy discussions and the development of long–term strategies.

6.4.6.2 The maximum runway throughput calculations assume an unlimited supply of aircraft and that only the laws of physics are applied when determining the runway capacity i.e. aircraft speed and strict application of minimum wake vortex separation rules (distances). There will initially be (at least) two rates for each airport – an optimum rate based on good weather conditions and a reduced rate based on adverse weather conditions, which may include poor visibility, unfavorable winds, or heavy precipitation.

- The optimum rate is defined as the maximum number of aircraft that can be routinely handled using visual approaches during periods of unlimited ceiling and visibility.
- The reduced rate is defined as the maximum number of aircraft that can be routinely handled during reduced visibility conditions when radar is required to provide separation between aircraft. This rate was determined for the most commonly used runway configuration in adverse weather conditions.

6.4.6.3 These benchmarks can be exceeded occasionally and lower rates can be expected under adverse conditions. Ultimately, where justified on the basis of benefit and cost analysis, a single uniform all weather capacity will be established for target aerodromes.

6.4.6.4 It should be an objective to utilize aircraft capabilities and navigation services in the most appropriate manner to move the all weather throughput as close to the visual throughput as possible. This may involve enhanced and timelier access for the more capably equipped aircraft.

6.4.7 Enhance Runway Performance

6.4.7.1 Achieving the optimum capacity from each runway is a complex task involving many factors, both tactical and strategic. In order to effectively manage that task it will be essential to measure the effects of changes and to monitor performance of the users and providers. It is important to make a distinction between the determination of the mathematical absolute level for Runway Occupancy Time (ROT), which will have an application in the planning of procedures and infrastructure, and the determination of practical and consistent values, which are commensurate with the operational environment.

6.4.7.2 The latter case will be applicable to the analysis of pilot and controller performance and must recognise the requirement to maintain the confidence of the users and to work within the existing culture of safety. A system of performance indicators, that form the basis of measurements and analysis, should be devised.

6.4.7.3 Tactical factors affecting runway occupancy include flight operations related items and ATM factors. The flight operations aspects include:

- operator performance;
- effects of company procedures;
- use of the airfield infrastructure; and
- aircraft performance issues.

6.4.7.4 Operator performance factors describe the elements affecting ROT that result from the actions or behaviour of the pilot. These, broadly, include experience, familiarity and awareness. Further factors are related to aircraft performance, such as spool up times, taxi speed and ground manoeuvre capability, landing weight/speed, use of deceleration devices (autobrakes, reverse thrust), and environmental factors, *inter alia*, cross/tailwind limitations and effects and runway surface conditions.

6.4.7.5 Operator company procedures aspects can include requirements following late changes to SID or take-off position, accomplishment of checks and procedures, reduced thrust operations, and aircraft configuration for environmental considerations (e.g., noise abatement).

6.4.7.6 Among airfield infrastructure issues are the location and visibility of RETs. Pilots need to be able to determine their position with respect to runway entry and exit points, as well as their speed (and deceleration) as early as possible during the rollout. There is a clear conflict between the safety of the aircraft, economic considerations (e.g. brake wear) and also the comfort of the passengers, and the desire to clear the runway at the earliest opportunity. While it is essential to avoid erosion of margins of safety, it is reasonable to expect that a more expedient use of runways can be achieved, with some performance advantage from tailoring deceleration techniques to individual situations.

6.4.7.7 The main flight operations elements that affect the occupancy time include, *inter alia*, braking distance, selection of runway exit, safe exit speed, pilot awareness of ROT requirements, autoland practices, and control handover practices. Collaboration between airline and aircraft operators, the airport operator, ATM providers and aircraft manufacturers will determine appropriate strategies to ensure consistency and predictability in ROT. This will include pilot and ATM provider awareness training, aircraft landing performance and braking system design, enhanced runway/taxiway design to facilitate runway entrance and exit at appropriate points, all-weather precision guidance to allow uniform operations in most conditions.

6.4.7.8 Runway occupancy time is not only related to landing aircraft. Departing aircraft are affected by factors that potentially induce delay on a runway. These factors include response to line-up/take-off clearances, essential pre-departure actions, spool-up, angle of entry to a runway, etc. Again, collaboration between airline and aircraft operators, the airport operator, ATM providers and aircraft manufacturers will determine appropriate strategies to ensure consistency and predictability in ROT. Coordination of arrival and departure operations on closely spaced parallel or converging runways can have a significant impact on ROT. The capabilities of modern aircraft systems should be exploited to mitigate this constraint.

6.4.8 Improve Movement Area Utilization

6.4.8.1 In most cases, the operation of the parking areas at an airport are the responsibility of either the airport operator, or the airspace user. No matter who is responsible, it is clear that parking area management can have a significant effect on the effectiveness of the ATM system.

6.4.8.2 The ability to get an aircraft from its gate to the departure holding point, or from the exit taxiway to gate, is critical to meeting performance expectations. A delay of 2-3 minutes at a parking area can have a significant flow on effect downstream.

6.4.8.3 To the extent that the airport owner/operator, airspace user and ground handling capability affect apron performance, the sum of these factors needs to be assessed within the framework of turn-around performance.

6.4.9 Enhance Runway/Taxiway/Apron Management

6.4.9.1 Improvements in this area lie in expediting the arrival and departure flows on the runway system and the movement of taxiing aircraft and other vehicles on the movement area, while reducing the potential for loss of separation.

6.4.9.2 Operational benefits will be in safety, capacity and cost. Benefits should also be expected in terms of reduced environmental impact with less noise, and less gaseous emissions, per surface movement. These procedures will aim at expediting the flow of taxiing aircraft and other vehicles on the movement area, while reducing the potential for surface traffic incidents.

6.4.9.3 Further improvement of aerodrome control service to traffic on the movement area will consist of enhanced conflict detection and alert means and procedures to improve the aerodrome surface movement throughput while maintaining or improving safety. Runway incursion monitoring and alert are covered by this improvement.

6.4.9.4 Operational Benefit will be in safety and capacity through improvements in the detection of conflicts between aircraft, aircraft and vehicles and aircraft and obstructions. Controllers have access to systems to help them develop and maintain situational awareness of all traffic on the movement area in all weather conditions.

6.4.9.5 The improvement of planning and routing is to enhance the aerodrome control service to inbound and outbound air traffic flows. This will be achieved through:

a) deconfliction; and
b) support of surface traffic management (it addresses the pre-tactical and tactical aspects of aerodrome control services).

6.4.9.6 This will be achieved in several ways, from simple changes in the planning and routing of aircraft (and vehicles), which will lead to safer and more optimal ground operations, to the introduction of automated guidance systems and technologies.

6.4.9.7 At many locations, airport structural improvements will result in significant efficiency gains. These include, *inter alia*, the installation of additional taxiways, parallel taxiways to main runways for two-way traffic flow to and from runways, additional runway exits including high speed or rapid exit taxiways, and better guidance lighting and signage. It is recognized that these structural changes may not be feasible, due to cost, or to restricted land availability.

6.4.9.8 At those locations where benefit/cost analysis shows a positive value, the improved guidance and control of taxiing aircraft and moving vehicles on the movement area as well as impending conflict alert may be fully automated. This is to be achieved through the phased implementation of A-SMGCS functionality (tools & procedures).

6.4.9.9 In all circumstances, provision will be made to allow operations to proceed unimpeded, in all predicted weather conditions. For any particular airport, an analysis of expected annual conditions will be made, expected weather minima (including visibility) determined, and taxiway design or guidance capability matched to those conditions. It is recognised that unexpected events may impinge on the capability of the taxiway element.

6.4.9.10 Where a high degree of reliability in apron management exists, the taxiway system and its management will be designed to allow free feed to and from those aprons. Where apron management is unreliable, as well as collaboratively managing that unreliability, provision will be made to ensure that an aircraft delayed on a taxiway awaiting a parking position does not impinge on overall taxiway operations.

6.4.10 Automated Tools for Arrival and Departure Sequencing

6.4.10.1 Through the medium term, at those locations where business case supports implementation, decision support tools will be developed and implemented to provide more structured management of arrival and departure streams from runways. These will build on baseline flow sequencing tools, which were available through the short-term evolution. The purpose of these tools will be to ensure that:

- the runway system(s) can be more efficiently used by establishing expedient runway allocations and generating schedules and advisories for aircraft crossing the metering fix;
- the accuracy of arrival time delivery at the metering fix relative to current operations is improved by displaying delay absorption advisories to air traffic management personnel to maneuver aircraft to match TMA schedule; and
- fuel-efficient trajectories are realized by adjusting the metering fix crossing time schedule to optimize the delay distribution function between ATM units. Fuel burn, emissions, and noise exposure are reduced without affecting runway system throughput and overall delay.

6.4.11 Dynamic Wake Vortex Detection and Mitigation

6.4.11.1 The optimization of arrivals and departures based on wake vortex detection and mitigation involves use of accurate knowledge of separation minima required by wake vortex generation, coupled with consideration of prevailing environmental or meteorological conditions. Benefits will be in safety, capacity and cost. This is to be achieved through the introduction of wake vortex detection systems, or improved understanding of wake vortex transitory characteristics. This will enhance the safety of aircraft operations during approach, landing and take-off.

6.4.11.2 The long term/ultimate objective is to reduce the minimum wake vortex separation by improving the wing/aircraft design and by introducing turbulence detection technology, which will increase the capacity benchmark. The technology can also assist in keeping the separation to a minimum even under adverse weather conditions, keeping the reduced rate as close as possible as the optimum rate.

6.4.11.3 Increased use of reduced procedural separations for non-intersecting flight paths, based on tight trajectory conformance bounds, will provide substantial en route and expanded terminal airspace operations. Lateral spacing down to wake vortex or other physical limitations can be supported. Precise vertical profiles and vertical intent information can provide substantially increased numbers of paths in transition airspace.

6.4.11.4 It is expected that many of the performance factors which provide arrivals benefits will also provide increased departure capacity as well as mixed operations capacity. Also, some of these same factors dealing with close parallel runway operations.

6.4.11.5 Parallel dependent runways, for example, are treated as an individual runway if one is being used strictly for arrivals and one strictly for departures. However, in VFR conditions, the runways behave independently with the caveat that approaches and departures on parallel paths must not violate wake vortex restrictions.

6.4.11.6 The factors that apply include:

- increased traffic management precision;
- precision knowledge of the airplane departure and missed approach trajectories, as well as the arrival and landing trajectories; and
- increased ability of the runway manager to sequence departures to maximize operations per unit time on the runway while satisfying both safety criteria: minimizing runway joint occupancy risk as well as wake vortex encounter risk.

6.4.11.7 Evolving capabilities have the potential to create different guided flight paths to the runway for various categories of aircraft. This capability should be assessed and developed to enhance airport capacity.

6.4.12 Collaborative Capacity Management

6.4.12.1 The ATM Operational Concept envisages a more strategic approach to air traffic management overall, and through CDM, a reduction in the reliance on tactical flow management. The ATM system is not a “closed system”, and is adversely affected by unexpected phenomena such as weather or other system disruption. It is inevitable therefore that tactical flow intervention will continue to be required;

however closer and timely coordination between users and service providers can ameliorate the need for “routine” tactical intervention that may be excessively disruptive. Flight dispatch options, recognition of onboard “required time of arrival” functions, strategic arrival slot allocation, in-flight re-clearance, strategic rather than tactical re-routes, can all be applied to reduce the reliance on tactical intervention.

6.4.12.2 Functionality in modern aircraft can be used to ameliorate a significant number of ‘disruptive’ events. This capability should be exploited with capable aircraft being released and cleared for operations that can benefit the efficiency of use of the airspace system. Reducing the number of aircraft subjected to ground holds, or airborne holding, will reduce the effect on those aircraft that are required to hold, and speed the recovery when the constraint is lifted.

6.4.13 Dynamic Management of TMAs

6.4.13.1 Terminal Area Design will include a set of integrated departure and arrival paths that allow maximum use of the available airspace while maintaining the highest level of operational safety. To the maximum extent possible, these paths should be used in only one direction and provide the least number of conflicts between departing and arriving flight paths

6.4.13.2 Arrival and departure procedures will provide a seamless flight path between an airport and the appropriate ATS route structure or vice versa. The use of standard routes (generally via SIDs/STARs) is encouraged so as to maximize system capacity, ameliorate environmental impact, reduce fuel consumption, and to reduce ATS coordination.

6.4.13.3 Once successfully inserted in the arrival sequence, four dimensional (4D) FMS-equipped aircraft will be managed through the following air-ground negotiation process to agree on their trajectory.

- Uplink of Constraints. The ground-based trajectory predictor sends the constraint list to the aircraft FMS by data link.
- Downlink of Trajectory. The FMS computes its own 4D trajectory based on the up-linked constraint list and returns it to ground by data link.
- Uplink of Clearance. The groundside checks the consistency of the trajectory in the flight database against the one computed by the ground-based trajectory predictor. If the new trajectory is conflict free, the database sends a clearance by data link to the aircraft to fly the trajectory.

6.4.14 Match IMC and VMC Operating Capacity

6.4.14.1 It should be an objective of the ATM system to utilize all airborne and ANSP capabilities to maintain Visual Meteorological Conditions (VMC) capacity during Instrument Meteorological Conditions (IMC) to the greatest practical extent. More use should be made of the capabilities of modern aircraft systems.

6.4.14.2 Local CDM processes at airports will build on sharing of key flight scheduling-related data that will enable all participants (airport, ATC, aircraft operators, ground handling) to improve their awareness of the aircraft status in the whole turn around process. This will allow minimal and precise Air Traffic Flow Management measures to be applied and higher predictability of schedules to be achieved. Benefits will include more efficient use of airport resources and ground handling, reduction in delays and especially the reactionary delays.

6.4.14.3 At airports this will manifest as a local integration of arrival and departure management functions together with further A-SMGCS implementations, e.g. guidance and control functions to optimize the runway and taxiways utilization and achieve a safe and efficient ground processing of every aircraft. Aircraft wake vortices will be actively monitored and the resulting information may be used in optimizing minimum separation. Benefits here will see increases in useable runway capacity and higher arrival and departure predictability facilitating higher annual productivity.

6.4.15 Enhance Surface Integration

6.4.15.1 Apron operations performance can have substantial and significant impact on the effectiveness of ATM operations as a whole. Apron operations include those services that affect an aircraft's operation from the time it reaches an apron after landing, to the time it has pushed back and is ready to taxi from the apron. It is the sum of those elements that contribute to the "turn-around time" of an aircraft. In some but not all cases, it will contain an element related directly to ATM (e.g. an imposed taxi delay to meet ATM requirements).

6.4.15.2 The ATM system as currently described is not configured to coordinate these activities. However, operators deal with them on a daily basis, and have clearly established procedures for managing the various components. Any one of these elements can lead to a delay against ATM agreed departure or arrival times, negotiated in some cases many months in advance.

6.4.15.3 In the evolution to the future ATM, CDM will extend to apron operations, though not necessarily directly involving ATM service providers in all negotiations. The responsibility for ensuring on-time or on-schedule delivery from the apron-to-taxiway boundary will rest with the airspace user operations component of ATM. The responsibility for ensuring that aircraft are delivered to the taxiway-to-apron boundary at the agreed time rests with aerodrome operations, as the primary interface into the ATM system.

6.4.15.4 The collaborative process between taxiway and apron will include:

- Development of guidelines for apron contingency planning at airports;
- Enhancement of apron capacity and efficiency by developing, promoting and monitoring the implementation of more uniform 'best practice' procedures;
- Development of techniques and procedures to maintain or improve the safety of apron airport operations, which may need to include the implementation of new technology;
- Optimization of airport apron infrastructure design, taking account of the local constraints;
- Development and deployment of procedures (and, where appropriate, automation) to improve operational efficiency through full data interchange;
- Improvement of gate management procedures at the interface between air and apron operations;
- Improvement of information-sharing and capacity management through CDM; and
- Development of guidance to reach the apron (lack of taxiway lighting) and implementation of Enhanced Flight Vision System (EFVS) for the business aircraft activity.

Enhancement of Airport Operations through Arrival Management

6.4.15.5 This improvement affects mainly runway utilization through 'sequencing and metering' provided by an automated arrival management function. Improved arrival management in combination with optimized runway utilization procedures and infrastructure will assure the capability to build a safe, continuous, expeditious and optimized flow of arriving aircraft towards, on and vacating the airport runway(s).

6.4.15.6 Operational benefits will be in safety, capacity, cost and environment. Capacity will result from achieving and sustaining maximum runway utilization and enabling optimal airport throughput. Reducing flying time will enhance cost and environment benefits.

Enhancement of Airport Operations through Departure Management

6.4.15.7 The enhancement of airport operations through departure management improves the runway utilization by sequencing and metering provided by an automated departure management function. Improved departure management will result in a continuous, expeditious and optimized flow of departing aircraft through the runway(s) until established en-route.

6.4.15.8 Operational benefits will be in safety, capacity, cost and environment. This will be achieved through creating a more orderly flow of departing traffic, minimizing ground delay and allowing more efficient use of the runway(s).

Enhancement of Operations through Fully Integrated Arrival, Departure and Surface Traffic Management

6.4.15.9 The enhancement of airport operations through fully integrated arrival, departure and surface traffic management will improve aerodrome throughput through the sequencing and metering provided by integrated arrival, departure and surface management functions. The full integration of Arrival, Departure and Surface Management will result in a safe, expeditious and orderly flow of arriving and departing aircraft. The surface traffic management function will also address the movement of ground vehicles on the maneuvering area.

6.4.15.10 Operational benefits will be in safety, capacity, cost and environment. This is to be achieved through building an optimized traffic flow from the top of descent through the airport to the top of climb. This will effectively eliminate ground and airborne holding, leading to a more optimum use of the airspace, the runway system and ground facilities with additional economies for airport and aircraft operators as well as the ATS provider.

Further Enhancement of Airport Operations from Chock to Chock

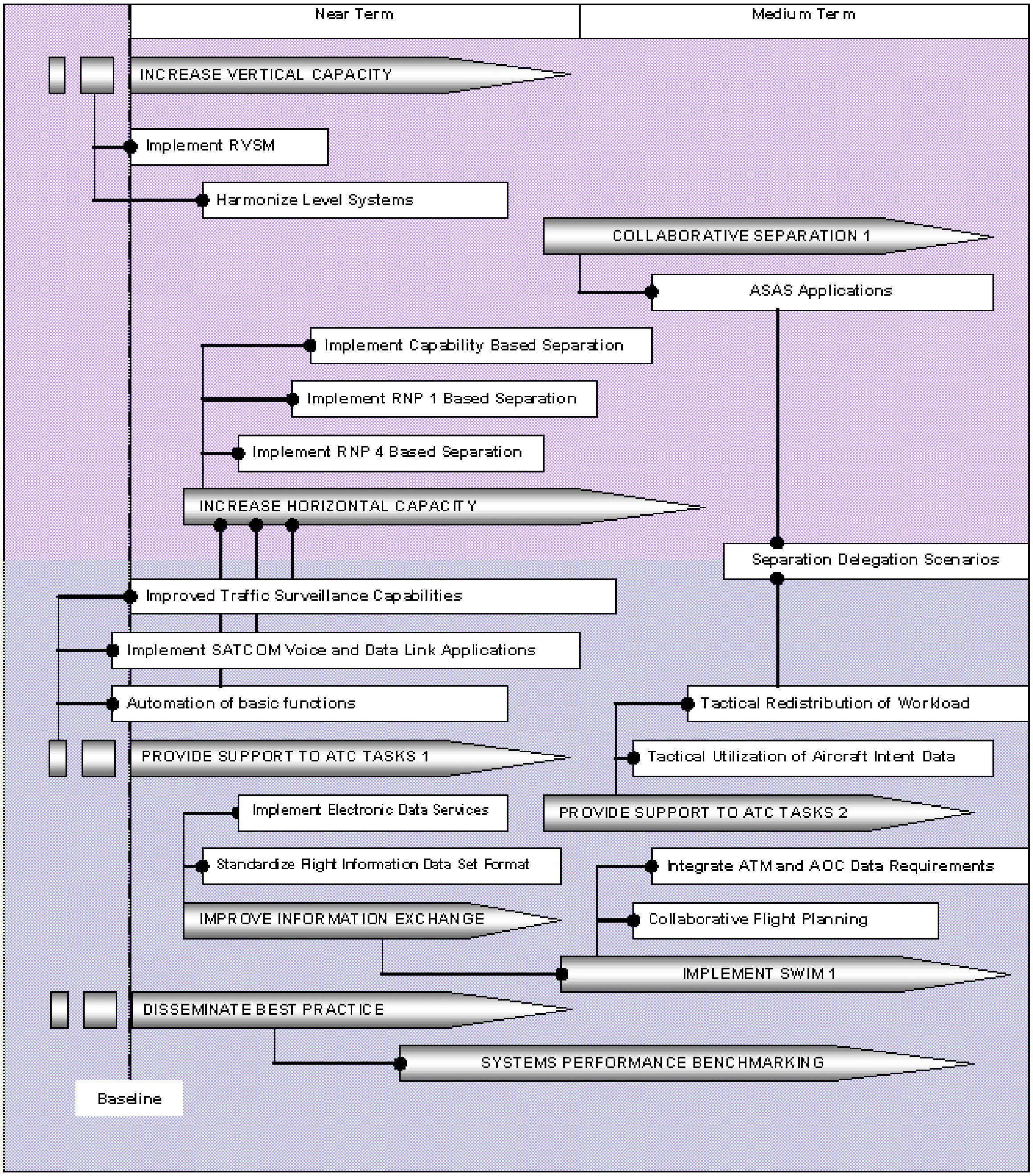
6.4.15.11 The further enhancement of airport operations from chock-to-chock addresses the use of automated support for integrated arrival, departure and surface traffic management, extending the planning horizon by including the departure and arrival aerodromes.

6.4.15.12 Operational benefits will be in safety, capacity, cost and environment. This is to be achieved through creating an optimized chock-to-chock flow of traffic. Flights will follow more efficient profiles and will be shorter in time.

Improved Surveillance Support For Ground Movement Management

6.4.15.13 Improved airport surveillance tools, in combination with proper aerodrome control procedures, will allow for better situational awareness and control of ground vehicle Meteorological Condition movements, especially in low visibility conditions and in darkness. Basic (passive) arrival manager tools will also become more commonly used. Benefits will include increased safety of ground movements due to better awareness of traffic, capabilities to control and more efficient airport ground movements.

6.5 ENROUTE CAPACITY AND SERVICE EFFECTIVENESS



6.5.1 Implement RVSM

6.5.1.1 A current strategy for increasing vertical capacity is the use of Reduced Vertical Separation Minima – RVSM. This provides 6 additional flight levels in upper airspace. It provides options in various application areas for enhancing capacity, efficiency, safety and/or cost-effectiveness. Refer ICAO Manual on RVSM Doc 9574.

6.5.2 Harmonize Level Systems

6.5.2.1 ICAO standards for units of measurement are based on the Systeme International (SI) (aka the metric) system of measurement. However, allowance is made for continuation of certain non-SI units, including the foot. The majority of States have retained the foot for altitude, elevation, height and vertical speed. Several States continue to use the metre.

Aircraft registered in States that have adopted the non-SI system have altimetry systems calibrated in feet. Those registered in States that have adopted the SI system generally have altimeters calibrated in metres. Aircraft operating across boundaries into States with another system are required to carry additional altimeters, or to use conversion charts. Air Traffic Controllers facilitating those flights are also required to use conversion charts.

The current standard for vertical separation effectively states that the nominal separation is 300 metres (1,000 feet) below FL290, and 600 metres (2,000 feet) above FL290, except where RVSM is in place.

6.5.2.2 Among States utilizing the SI system, for RVSM some adhere to the ICAO Table of Cruising Levels, whereas some other States apply different vertical separation standards.

6.5.2.3 Significant safety and workload issues arise from the application of two different units of measurement for vertical separation both from a pilot and a controller viewpoint. The implementation of RVSM by States with contiguous airspace, with one State using the metre and the other using the foot, has exacerbated the issue. In the case of States utilizing the metre, lack of adherence by some of those States to the ICAO Table of Cruising Levels has resulted in the loss of several cruising levels, and thus additional capacity that would have otherwise been available and penalizes aircraft operating on long sectors. The States concerned are therefore urged to adhere to the ICAO Table of Cruising Levels.

6.5.2.4 Standardization worldwide upon a single unit of measurement will enhance safety and simplify operations both in the air and on the ground. The future ATM system should therefore be predicated on the indefinite retention of the foot (the predominantly used unit for altitude designation and the vast majority of aircraft are so equipped) and transition to the foot from the metre where currently in use.

6.5.3 Implement RNP 4 Based Separation

6.5.3.1 Required Navigation Performance (RNP) as currently defined by ICAO specifies a number of agreed horizontal navigation containment values. RNP 20 and RNP 12.6 are unlikely to be implemented at any time. RNP 10 has been implemented in certain oceanic and remote areas, and has resulted in useful increases in operating efficiency. RNP 4 approval processes have been agreed, and separation minima of 30NM have been promulgated in Annex 11, and Doc 4444 PANS-ATM. It should be recognized that in the European RNAV space, equipage standards for Basic RNAV (B-RNAV), corresponding to RNP-5, have been established. Where possible, interoperability between B-RNAV and RNP-4 capable aircraft should be encouraged.

6.5.3.2 The implementation of RNP 4 based minima of 30NM requires surveillance by FANS-1/A Automatic Dependent Surveillance - Contract (ADS-C), and direct communications including FANS-1/A Controller Pilot Data Link Communications (CPDLC). Increasingly, there is high fleet equipage with FANS ADS-C and CPDLC among air carrier operations, and States should take advantage of that equipage to introduce phased reductions in spacing between aircraft starting with longitudinal spacing where higher minima are currently applied.

6.5.3.3 States should also recognize the containment value presented by RNP 4 capable aircraft in designing air routes, and in particular, in facilitating the transit of previously constrained airspace. This includes the definition of tracks avoiding terrain, or restricted airspace. This may be supported by the ability to transmit ADS-C position, and to communicate via CPDLC, where other surveillance or communication infrastructure is not available or suitable.

6.5.4 Implement RNP 1 (or equivalent) Based Separation

6.5.4.1 ICAO specifies as the current lowest en-route horizontal navigation requirement RNP 1. While the upgrade of all aircraft to RNP-1 capability will extend beyond the near term, States should take advantage of the performance characteristics that are currently available to design route structures that allow closer horizontal spacing between aircraft. Near-term benefits can be achieved by applying RNP-1 criteria to the transition airspace between en-route and airport approaches. Further application to enroute airspace should be targeted for the mid-term.

6.5.4.2 The PRNAV implementation has commenced in Europe should be used as a model for reduction in horizontal spacing pending implementation of RNP 1.

6.5.5 Implement Containment Based Separation

6.5.5.1 The initial concept of RNP established by ICAO was a navigation accuracy standard based on 95% probability of remaining in the designated RNP value for the airspace. Modern aircraft systems have been designed with this concept expanded to add the concept of containment. Containment adds significant additional confidence that the overall navigation performance is contained to a factor of the RNP value (e.g., 2 times) to a high probability. The containment concept can be used to classify and separate airspace more efficiently and should be implemented as soon as practical when aircraft equipage will support and on a non-exclusionary basis.

6.5.5.2 This equates to recognition of an “actual navigation performance” of the aircraft. Recognition of that performance in combination with appropriate Communication and Surveillance capabilities will allow reduction in horizontal spacing.

6.5.5.3 The nomenclature for ICAO RNP concept and the RNP RNAV containment concept should be harmonized to minimize confusion.

6.5.5.4 In addition to RNP, capability-based separation potentially entails Required Communication Performance (RCP), and Required Surveillance Performance (RSP). In terms of RCP, future voice/data communication technologies need to be explored. Similarly in terms of RSP, future technologies, such as the appropriate ADS-B link(s) and associated redundancies, also need to be explored.

6.5.6 Separation Delegation Scenarios

6.5.6.1 Delegated separation is a situation where separation assurance remains the responsibility of ATM but with authority delegated to flight crews for specific operations. "Station-keeping" between aircraft is the most obvious application since it involves low relative velocities and stable positions, but other merging, over-taking and crossing applications are also being considered.

6.5.6.2 The strategy, therefore, is to exploit delegated separation in less dense en-route / oceanic airspace and final approach spacing at secondary airports as initial applications – more for flight efficiency reasons than for capacity.

6.5.7 Initial ASAS Applications

6.5.7.1 Flight deck situational awareness of surrounding traffic, and applications deriving from it, are now an established trend, with the technology already existing (in ACAS II) and a requirement to expand its use beyond safety nets. There are clear benefits in bringing safety and extended operations to areas where little or no ATC infrastructure exists. Better traffic awareness will come from Airborne Separation Assistance Systems (ASAS) rather than Traffic Collision Avoidance System (TCAS). ASAS is an enhancement of ADS-B based surveillance and enhanced Cockpit Display of Traffic Information (CDTI).

6.5.7.2 Initial applications of ASAS will see better traffic awareness on the flight deck, and may provide opportunities for transfer of separation responsibilities to the flight deck in certain circumstances.

6.5.8 Reduction of air/ground communication workload

SATCOM voice communications

6.5.8.1 SATCOM voice communications have the potential to offer advantages in > terms of safety and workload as an alternative to HF voice. However, current ICAO PANS and SUPPS limit the use of SATCOM voice to emergency and non-routine communications. In the expectation that the outcome of the current trials of SATCOM voice for routine position reporting being conducted in the NAT Region will be successful, this should form the basis for the global acceptance of the use of SATCOM voice as an alternative to HF voice.

Implementation of data link applications

6.5.8.2 Air-ground data link applications (CPDLC) can bring significant advantages in terms of workload and safety over voice communication for both pilots and controllers. In particular they will result in a better understanding of instructions and read backs, reduction of frequency occupation, and faster response times compared to High Frequency (HF) voice. The reduction of workload per flight translates into capacity increases and enhances safety.

6.5.8.3 In keeping with the principle of interoperability, airborne and ground requirements for ATN and FANS CPDLC operations must be harmonized.

6.5.9 Support to ATC Tasks 1 and 2

Automation of Basic Functions: Support to ATC coordination

6.5.9.1 The automation of the ATC coordination tasks between adjacent sectors increases the predictability and quality of information on traffic transiting between sectors, thereby allowing reduced separations, a reduction of the workload associated to these tasks, and increasing capacity and flight efficiency.

Automation of Basic Functions: Support to tactical traffic planning & conflict management

6.5.9.2 For early resolution of planning conflicts basic levels of 'what-if' probing functionality will become available enabling to optimise the conflict resolution strategy, reducing the need for tactical action, thus making the executive role available for handling more traffic within the same acceptable workload limits.

6.5.9.3 A planning function over several sectors will allow a better preparation of the sector traffic situation (smoother flows with less potential conflicts and better taking into account arrival schedules). This allows the sector team to operate more effectively and will result in more optimum and efficient arrival flows.

Improved traffic surveillance

6.5.9.4 The further implementation of surveillance techniques will allow to reduce separation minima and to increase safety, capacity, flight efficiency and cost--effectiveness. This will be achieved through ADS-C or ADS-B where no surveillance is possible today or at better costs, allowing to dramatically reduce separation minima and decrease both the situations on which controllers would otherwise intervene and the workload for a resolution. In airspaces where radar is used, enhanced surveillance can bring further separation minima reduction and in high traffic density areas, will improve the quality of surveillance information, therefore increasing safety levels and the confident use of actual separations close to the minima.

6.5.10 Support to ATC tasks 2

Support to tactical traffic complexity management

6.5.10.1 With automation support making use of precise trajectory computations and information on intents, ATC will be able to manage the traffic flow quality (with respect to bunching, complexity, etc.) through groups of sectors. This will allow a tactical redistribution of anticipated workloads among sectors and allow each sector to safely operate at near-maximum capacity.

Advanced tactical support using aircraft intent data

6.5.10.2 Data link support will enhance the collaboration between controllers and cockpit crew by linking on-board and ground side automation. The latter will actively support controllers in resolving any potential traffic problems well in advance. The productivity of the sector team will be further enhanced by facilitating new automation support capabilities that make maximum use of information shared with the aircraft.

Tactical Redistribution of Workload

6.5.10.3 Refer ASAS and Separation Delegation Scenarios – paragraphs 7.16.1 and 7.17.3.

6.5.11 Standardize Flight Information Data Set Format

6.5.11.1 In order to facilitate the safe coordination and interchange of data between FMS aircraft and ATM service providers, it is essential that a common data set format be agreed and implemented.

6.5.12 Develop and Implement Electronic Data Services

6.5.12.1 Improvements in aeronautical information services – and expansion of the traditional role – will facilitate Electronic Data Services (EDS). EDS is a major step toward "e-enabling" the entire air user system — from the flight deck to the cabin, maintenance, and the airport. EDS will provide key, meaningful information to pilots, flight attendants, operations workers, mechanics, and other personnel. An example of EDS is the Electronic Flight Bag (EFB).

6.5.12.2 Operators should realize many benefits with the EDS, based on the ability to execute performance-based calculations. The provision of the results of aircraft performance calculations are expected to be part of the CDM exchanges which will be used to improve the overall ATM service productivity. (Examples could include performance based climb/descent rate clearances, etc.) There will likely be additional benefits to airspace users separate from the improvements in airspace operations.

6.5.12.3 EDS can also provide improved taxiway safety. The taxiway environment can be challenging for pilots, especially when visibility is limited or during the night at unfamiliar airports. EDS can enhance pilot runway and taxiway situational awareness by integrating onboard geo-referencing equipment with electronic airport taxi maps. Pilots will have greater awareness of position — from the runway to the gate — which improves safety and reduces taxi time.

6.5.13 Integrate ATM and AOC Data Requirements

6.5.13.1 Innovative data exchanges and shared automation tools distributed among flight operation centers (FOC) using aeronautical operational control (AOC) communications, and ATM service provider units provide substantial benefit to both users and service providers. The enhanced CDM process will ensure timely operational decision-making, allowing both the AOC, and the ATM service provider to act on a flight or series of flights to ensure optimum system flow.

6.5.13.2 Unpredictable weather disruptions increasingly require manual intervention by flow management personnel to route aircraft around crowded airspace and to coordinate flows across multiple ATM service provider units. The challenges for new automation concepts lie in the computational complexity of dynamic airspace constraints, as well as in the equity considerations of allocating scarce resources to individual flights, belonging to different airlines and user segments, that sometimes cross multiply constrained resources.

6.5.14 System Wide Information Management (SWIM)

6.5.14.1 The information management service will have to provide timely flight plans and flight plan updates consistent across separation, traffic and flow management services for the flow management service to meet its expected overall performance requirement. Information availability is assumed. It is assumed that a system exists that is capable of handling the required data exchange between system agents, data storage, and data distribution.

6.5.14.2 Unprecedented access to data through the information management service will enable a rigorous and pervasive use of fully flexible airspace boundaries within the system. Airspace management procedures and airspace design permit the creation, allocation, dynamic use, and reallocation of defined airspace regions that accommodate the individual needs of military (including high performance aircraft), civilian (including supersonic aircraft), and non-military space system users. The conversion of airspace management from a strategic to a tactical function enables sharing of the workload across sectors and alleviates restrictions on unused airspace, enabling more equitable and efficient utilization of airspace among all system users.

6.5.14.3 SWIM enables:

- Reporting and prediction of air traffic and overall system information, both ground and air-based.
- Reporting, prediction, and update rates for weather and other environmental characteristics.
- Knowledge, quality and prediction of intent information, both ground and air-based. Identification, quantification and prediction of relevant system uncertainties.

6.5.15 Collaborative Flight Planning

6.5.15.1 Participation in decision making in flow management in the some States has in recent years included a significant involvement by airspace users, through the CDM paradigm. CDM includes significant data exchange and shared automation tools for AOC communications, the ATC system command center (SCC) and traffic management in ATC en route centers (ARTCC). CDM is also being explored in the European system, with a number of unique challenges including the fact that the computational complexity of the airspace constraint problem is significantly higher than the single airport problem in the US system. The “ration by schedule” (RBS) concept applied in US CDM may have an analogy in the sector network problem, but is clearly considerably more complex. Additionally, questions about equity in allocating scarce resources become significantly more difficult when each flight crosses multiple constrained resources.

6.5.16 Dissemination and use of best practices

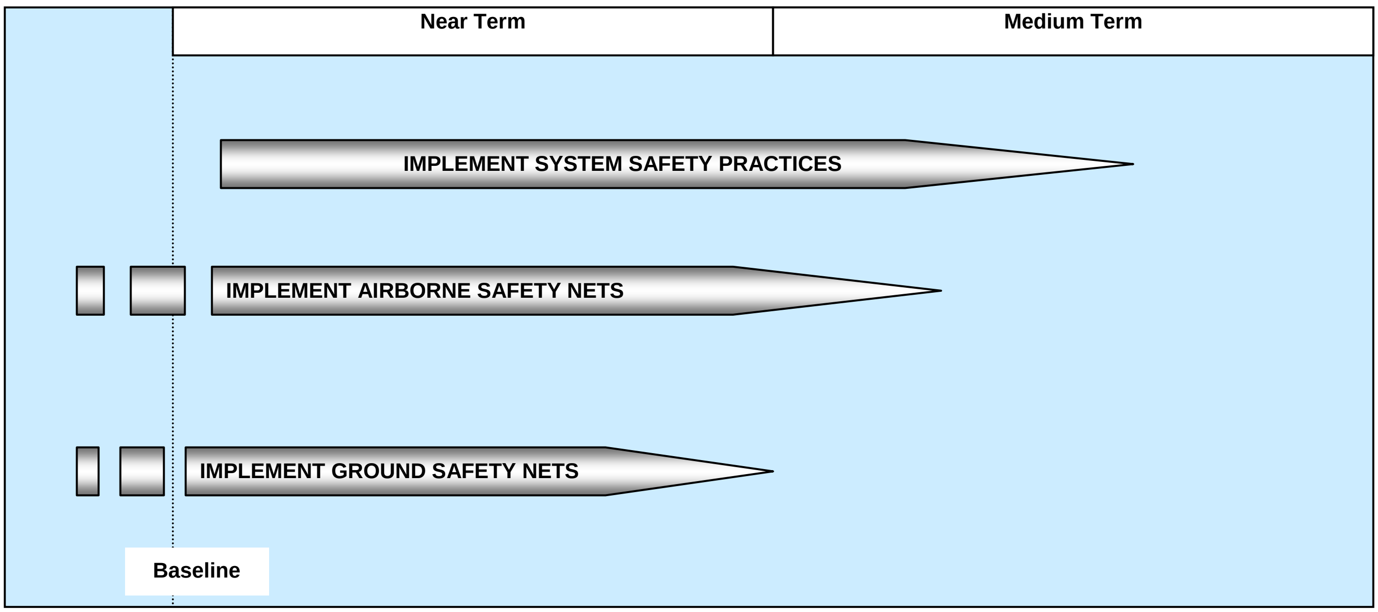
6.5.16.1 The dissemination and use of best practices addresses all facets of the ATM system, procedures, technical systems, human resources and management.

They sometimes mean mainly a cultural rather than an infrastructure change and can bring very significant operational and cost-efficiency benefits. Under this category is included the leveraging of the ATC services and flight operations in some States.

6.5.17 Use of benchmarking

6.5.17.1 Benchmarking encompasses process and techniques, which include a regular comparison analysis of the performance of different systems, using quantitative criteria. The analysis also searches the reasons for differences in performance. Widely used in many industries including airlines, its application to the ATM system is a powerful instrument to create incentives for adapting the system to the expectations, and to ensure the widest application of best suitable practices, thereby contributing to its optimization.

6.6 SAFETY NETS



6.6.1 Implement System Safety

6.6.1.1 Refer to Appendix F of the ICAO ATM Operational Concept Document (Air Navigation Conference 11-WP/4).

6.6.2 Airborne safety nets

6.6.2.1 The global implementation of ACAS II will improve safety worldwide. Other airborne safety nets, such as Terrain Awareness and Warning Systems (TAWS), reduce the risk of collisions with the ground. These safety nets are used as a last recourse in cases where normal procedures and separation minima have not been observed.

6.6.3 Ground safety nets

6.6.3.1 Ground safety nets, such as short-term conflict alert, minimum safe altitude warnings etc. provide ATM service provider personnel with alarms in situations where it is predicted that separation minima could be violated. They increase safety levels in the system.

7. Use of Existing or Emerging Capabilities to Support ATM Enhancements

> It is essential that the capabilities and system capacities offered by existing aircraft equipage, ATM infrastructure and air traffic control systems be utilized to the maximum extent possible to deliver transitional benefits while the future system is being developed.

7.1 Considerable investments have been made by ATM community members in developing and equipping with capabilities, many of which are under-utilized or not utilized at all. These include airborne and ground based capabilities, in the areas of air traffic management, and communications, navigation and surveillance, as well as information transfer. It is essential that the capabilities and system capacities offered by existing aircraft equipage, ATM infrastructure and air traffic control systems be utilized to the maximum extent possible to deliver transitional benefits while the future system is being developed. It should be recognized that within and across user communities there is broad variation in current equipage and capabilities.

7.2 While section 6 identified ATM enhancement areas, this section begins to map those operational enhancements that may require support, against the existing/emerging technologies/capabilities. In assessing solution sets for a particular enhancement, the ATM community must recognize that the common denominator in aviation is the airspace user, and in particular international air transport and many business and general aviation aircraft, who regularly transit Regions and States, and who, in accordance with the global goal of seamless ATM, are seeking to carry the minimum defined set of standardized and commonly applied avionics and equipment.

7.3 This section should also be read in conjunction with Appendix E, which outlines the considerations of airspace users and service providers in both forward-fitting and retro-fitting equipment to meet a particular ATM enhancement requirement. It should be noted that this material outlines example cases – there may be other options or solution sets.

<u>NEAR-TERM ENHANCEMENTS</u>

Focus Area: En-Route Efficiency

7.4 Category: Flexible Airspace Management

7.4.1 Enhancement(s): Flexible Use Airspace
Reference: 6.3.2

7.4.1.1 Flexible use airspace depends on effective communication between all parties. For planning purposes ATM Service Providers and Airspace Users will require terrestrial communications. Flexibility shall be provided so that Airspace Users who do not have a centralized dispatch function will not be excluded. For tactical management, ATM Service Providers and aircraft will require data link communications for the uplinking of revised flight plans. In the near term, voice clearances could be used.

7.4.1.2 The networks and links to support the terrestrial communications exist today. Most major telecom providers can establish Virtual Private Networks (VPNs) in each of the world's main traffic regions. The Communication Service Providers, ARINC and SITA can provide global VPNs.

7.4.1.3 To manage Flexible Use Airspace, there will be a need for the establishment of dynamic databases and repositories for traffic data, which would be hosted at regional facilities. The formats and procedures governing the use of these facilities would have to be developed. Additionally, the agreements would have to be worked out related to institutional issues such as ownership and responsibilities for these systems. The management and oversight of the databases would be simplified if the responsibility for them were handed over to Regional ATM Providers.

7.4.1.4 Examples of dynamic databases already exist, *inter alia*, the United States Aircraft Situation Display (ASDI) and National Airspace System and Status Information (NASSI). These database systems should be examined to evaluate general implementation. Additionally, recommendations should be made to improve the system to be able to handle implementation by Regional ATM Providers.

7.4.2 Enhancement(s): Align Upper Airspace Classifications Reference: 6.3.3

7.4.2.1 A number of regional authorities are in the process of transitioning to Reduced Vertical Separation Minima (RVSM) airspace above Flight Level 290 (FL 290). Asia, Europe, North and South America will or have completed RVSM airspace implementation during the near term. As a result, large portions of the world's air carrier fleet and a majority of the business aviation fleet is already RVSM compliant or will be during the near term. The effort of worldwide standardization of RVSM above FL 290 should be completed during the near term.

7.4.2.2 Imperial units are the historical standard for aviation altitude designation and the vast majority of aircraft are so equipped. An entirely flexible airspace structure is the goal of the mid term, which will be facilitated by imperial units remaining as the standard for altitude designation.

7.4.3 Enhancement(s): Collaborative Airspace Design Reference: 6.3.5

7.4.3.1 Today's airline and business aviation fleets are more and more equipped to operate using area navigation (RNAV) capabilities, the rate of which should be considered when airspace redesign programs are undertaken regionally. It should be recognized that area navigation has moved from relying on a ground based system of navigational aids to a space based system. This transition will continue through the near-term making area navigation primarily space based by the mid-term. This is especially true for the business aviation fleet.

7.4.3.2 Most airline Flight Management Systems (FMS) provide a Required Time of Arrival (RTA) function. This function allows a time constraint to be placed on a selected flight plan waypoint, with guidance (e.g., speed control) provided to ensure the aircraft arrives at the waypoint at the defined time. The pilot is notified following the time entry if the constraint cannot be met within the aircraft's performance envelope. Most RTA functions allow for only one RTA constraint to be entered, although some systems support multiple constraints. Most existing business aviation FMS do not support an RTA capability although they do provide time of arrival predictions for all flight plan waypoints. It is expected that in future generations of FMS for business aviation aircraft, RTA capability will be included.

7.4.3.3 Operations in domestic airspace are generally conducted under radar contact with radar separation being utilized. The use of the RTA function in this case is acceptable. While operating in an oceanic or remote airspace separation in either time or distance based. In order to maintain separation aircraft must maintain a constant Mach and disregard reaching a waypoint at a specific time. In oceanic or remote airspace operators are told that if they will not make their ETA at a waypoint within ±3 minutes they are to update their estimate only. Therefore, in oceanic or remote airspaces the RTA function is of little value.

7.5 Category: Enhanced Route Flexibility

7.5.1 Enhancement(s): Area Navigation
Reference: 6.3.6

7.5.1.1 Area navigation pertains to method(s) of navigation that enables aircraft to fly on any desired flight path within the coverage of referenced navigation aids (NAVAIDS) or within the limits of the capability of self-contained systems, or a combination of these capabilities. Routes and procedures using RNAV are not restricted to the location of ground-based NAVAIDS.

7.5.1.2 Depending on the level of required performance (see 7.5.2), DME/DME, VOR/DME, GNSS, inertial navigation, as well as emerging technologies such as SBAS (e.g., WAAS, EGNOS, and MSAS), support RNAV route (e.g. Q routes) requirements.

7.5.1.3 The majority of business, general aviation, and airline aircraft are capable of some type of area navigation operations.

7.5.2 Enhancement(s): Performance Based Navigation
Reference: 6.3.7

7.5.2.1 Increasingly, navigation applications are based on performance standards and metrics, rather than specific technologies and equipage configurations. These performance-based concepts for navigation are captured under Required Navigation Performance (RNP) (as described in ICAO Doc 9613).

7.5.2.2 The initial concept of RNP established by ICAO was a navigation accuracy standard based on 95% probability of remaining in the designated RNP value for the airspace. This concept has been extended to cover RNAV operations with navigation containment and monitoring. Compliant systems must ensure navigation error does not exceed 2x RNP value more than 1 in every 100,000 per hour. An ICAO working group is assigned to clarify the RNP nomenclature.

7.5.2.3 In Europe, Basic RNAV (B-RNAV) based on aircraft equipage, corresponds to RNP-5. Precision RNAV (P-RNAV), corresponds to RNP-1.

7.5.2.4 A combination of technologies based on ground infrastructure such as DME/DME navigation, space-based systems such as GPS and Galileo, augmentation systems such as SBAS (e.g., WAAS, EGNOS, MSAS) and GBAS (e.g., LAAS), predictive algorithms based on senor availability, and aircraft inertial sensors, alone or in combination will be required to meet various levels of RNP.

7.5.2.5 In keeping with the principle of interoperability, international requirements of RNP (e.g. system integrity) need to be harmonized.

7.5.2.6 The majority of FMS-equipped business aviation and airline aircraft are capable of being approved for RNP (95%) operations. Containment-capable systems are now being introduced on new production aircraft and with FMS upgrades.

7.5.3 Enhancement(s): Dynamic Route Management
Reference: 6.3.8

7.5.3.1 Dynamic route management involves the aircraft in the planning process. Typical scenarios include the generation of routing requests by the airspace users, the processing and approval of these requests by ANSPs and their transmission to aircraft. Advanced scenarios would have the aircraft making requests directly to ANSPs who would process and modify the request if necessary and then forward the approved route to aircraft.

7.5.3.2 The technology to support this exists today. Airline long-haul aircraft have the capability to receive and activate routes transmitted via data link. Current generation data link systems are already supporting User Preferred Routes in oceanic airspace. Questions have been raised about the capacity of the existing data link systems to handle such exchanges in busier airspace environments. The current VHF Communication Service Providers will continue implementing VDLM2 to meet airspace users and ANSPs requirements. Given the demonstrable substantial improvement in performance, use of this data link technology should be considered for this enhancement.

Focus Area: TMA/Airport Efficiency/Capacity

7.6 Category: Enhance TMA Management

7.6.1 Enhancement(s): RNAV Arrivals/Departures/RNP RNAV SIDs and STARs
Reference: 6.4.3

7.6.1.1 Ongoing development and implementation of RNP based RNAV SIDs and STARs will increase capacity by offering more lateral path options for designers to effectively manage outbound/climbing and incoming/descending traffic. More efficient lateral path options and vertical path options will improve operational costs through improved performance capability utilization.

7.6.1.2 SID and STAR procedures are supported by business aviation and airline FMSs via their onboard databases. Published SID and STAR procedures that contain predefined constraints, both longitudinal (speed constraint) and vertical (altitude at waypoint), which are defined by state authorities must be selectable by the pilot for automatic insertion into the active flight plan.

7.6.1.3 Tailored Arrival Procedures (TAP) are facilitated by uplinking optimized arrival procedures to the aircraft. FANS-1/A CPDLC capability available today on many airline aircraft provides a mechanism for uplinking TAP waypoints. Initial ATN CPDLC capability generally does not include the ability to activate the uplinked TAP in the FMS flight plan. This capability would need to be added to support TAP operations.

7.6.1.4 To ensure continued safety, navigation data such as the FMS database and electronic navigation charts should comply with RTCA/DO-200A and/or EUROCAE ED-76 standards that govern standards for processing aeronautical data. Europe has already established the requirement for databases to meet DO-200A integrity requirements for PRNAV.

7.6.2 Enhancement(s): Optimized Arrival Procedures Reference: 6.4.4

7.6.2.1 Modern RNP RNAV based arrival design from STAR through approach should maximize lateral path options to improve efficiency, reduce controller workload, and reduce communication requirements. Sequencing requirements may be managed by utilizing the Required Time of Arrival FMS function (ref. 7.4.3.2). Continuous Descent Arrivals (CDARR) based on a 3° to 4° path will improve operational efficiency through reduced fuel costs, reduced level change activity, and reduced communication requirement. Where arrival procedures (descents) conflict with departure procedures (climbs), CDARR design should be given priority including the use of steeper descent path angles. Descent path performance capability exceeds climb path performance capability, therefore, the currently adopted procedure of descending traffic well ahead of user preferred trajectories and below climbing/outbound traffic should be reversed. Additional potential benefit obtained from maintaining cruising levels for longer periods is the reduced opportunity for encountering adverse operating conditions. CPDLC and enhanced surveillance capabilities will further optimize system capacity and predictability.

7.6.2.2 There are three types of VNAV descents supported by existing aircraft FMSs. Most FMSs provide idle power, constant airspeed and geometric path descents. Idle power, constant airspeed (sometimes referred to as 'flight level change') descents reduce thrust to idle at the top of descent and maintain a constant airspeed during the descent. These descents do not provide a predictable path or arrival location at the bottom-of-descent level-off altitude and are therefore not applicable to optimized arrival procedures. Geometric path descents vary thrust to follow a defined descent path in space at a constant airspeed. This VNAV descent mode is appropriate for optimized arrival procedures although it doesn't provide an optimized minimum fuel descent profile. The third type of VNAV descent is the minimum energy descent. With this descent mode, the FMS computes the optimum (parabolic) descent profile resulting in the minimum fuel burn while adhering to the specified descent constraints. These descents will not result in a repeatable path although they will arrive at defined descent altitude constraints at the specified waypoints and therefore could be applied to optimized descent procedures depending on the airspace flexibility during the descent. Minimum energy descent capability is found primarily on airline aircraft. Business aircraft currently do not have this capability, but, if possible, should be considered in the future.

7.6.2.3 See also section 7.15.1 for discussion on dynamic management of TMAs.

7.7 Category: Enhance Runway Operations

7.7.1 Enhancement(s): Enhance Runway Performance Reference: 6.4.7

7.7.1.1 Runway capacity constraints are defined by procedures, surface area design, aircraft performance capabilities, surveillance capabilities, aircraft spacing, and weather limitations. Improved procedures for minimizing spacing such as Precision Runway Monitoring (PRM) and RNP RNAV approaches for closely spaced parallel runways will optimize spacing capability. Implementation of A-SMGCS and or ADS-B offers a near term solution to reduce Runway Occupancy Time (ROT). Use of 1090 MHz Extended Squitter (1090ES) ADS-B will serve to enhance the PRM and RNP RNAV procedures to any runway configuration as well as provide a seamless surveillance transition from airborne to surface movement management. Continued acceptance and deployment of aircraft based Enhanced Vision Systems will provide VMC capability in IMC environments to further improve ROT through improved situational awareness. Aircraft based surface moving map display will further enhance surface movement operations.

7.7.1.2 Application of containment-based RNP concepts, e.g. RNP-0.3/0.1 to closely spaced parallel runway approaches would also increase runway traffic throughput.

7.7.1.3 Synthetic vision, based on detailed airport map, can enhance situation awareness under adverse weather conditions where runway/taxiway markings may be obscured.

7.7.1.4 Head up display and guidance systems that can synthesize enhanced vision sensor data and synthetic vision images can offer an integrated solution to enhance situation awareness.

7.8 Category: Enhance Airport Management

7.8.1 Enhancement(s): Improve Movement Area Utilization Reference: 6.4.8

7.8.1.1 Efficient use of parking areas requires communication between all parties to permit smooth traffic flows. This is essential to reduce ramp overcrowding and also blocking of other aircraft in the parking area. Service vehicle movements must be included in this communication and coordination. Data link communication such as ACARS for push-back clearances and 1090ES ADS-B must be encouraged to ease radio congestion and also enhance overall on-ground situational awareness.

7.8.2 Enhancement(s): Enhance Runway/Taxiway/Apron Management Reference: 6.4.9

7.8.2.1 One of the key technology tools needed to achieve this benefit is A-SMGCS. Although there are a number of candidate technologies, 1090ES has been endorsed by the aviation community and can be readily implemented in many aircraft. In this case, retrofit on many aircraft can be achieved with a short lead-time. ATM service providers should be encouraged to implement A-SMGCS ground systems including multilateration with the Mode S transponders already fitted to most of the aircraft today.

7.8.2.2 Addition of position reporting via data link along with visual display is essential to the improvement of safety and efficiency of ground operations. On the aircraft, the ability to receive ADS-B data (ADS-B in) or Traffic Information System – Broadcast (TIS-B) and display the received traffic data on a Cockpit Display of Traffic Information (CDTI) will greatly enhance the pilot's contribution to increasing airport surface safety and efficiency. These capabilities are growth functions of current generation TCAS and display systems.

7.8.2.3 A method of conflict alerting should be implemented. Conflict alerts could be forwarded from ATC or computed on the aircraft.

Focus Area: En-Route Capacity

7.9 Category: Increase Vertical Capacity

7.9.1 Enhancement(s): Implement RVSM
Reference: 6.5.1

7.9.1.1 Continuing Reduced Vertical Separation Minima above FL290 in accordance with existing ICAO guidance will increase system Vertical Capacity in geographic areas not presently utilizing RVSM. The RVSM compliance rate among business airplanes less than ten years of age is in excess of 70 percent, while older airplanes have a compliance rate below 20 percent.

7.9.2 Enhancement(s): Harmonize Level Systems
Reference: 6.5.2

7.9.2.1 Most newer aircraft and avionics packages have the ability to switch the aircrew displays between metric and imperial units. Older equipment will require continued use of conversion charts by both the aircrew and Controllers.

7.9.2.2 Harmonization of airspace is needed when adjoining States do not both utilize metric or imperial altitudes. If such harmonization cannot occur then procedural improvements are needed when an aircraft operates across boundaries between metric and imperial units airspace. Today there is no formal statement of changeover, simply a Controller announcement of "continue at XX Metres" when previously the aircraft was cleared at FLYYY. Enhanced procedures to clearly state and confirm the changeover will increase safety.

7.10 Category: Increase Horizontal Capacity

7.10.1 Enhancement(s): Implement RNP 4 Based Separation
Reference: 6.5.3

7.10.1.1. RNP-4 is based on ICAO-definition of 95% position accuracy. In the oceanic regions, RNP-10 operations will evolve to RNP-4 operations as dictated by traffic demands in the various regions.

7.10.1.2 RNP-4 based on containment concepts is emerging. RNP-4 containment (e.g., DO-236compliant) capability is included in many new production aircraft. Containment-based RNP-4, in combination with FANS-1/A CPDLC and ADS-C, supports 30/30 nm separation. Containment-based RNP-4 along with more stringent direct communication and surveillance requirements can lead to further reduction in separation.

7.10.1.3 Until confidence has been gained in the aircraft's ability to maintain its cleared trajectory, regular or periodic position reporting will be required in addition to event reporting. As separation is reduced, the rate of position reporting must increase to maintain a given target level of safety. For the separation reductions under consideration, data link is the only viable means of achieving the required reporting rate without creating communications clutter.

7.10.1.4 Deviations from set minima can be indicated to ATC by way of ADS-C "Event Contracts". No data link system is infallible; hence these should also be accompanied by ADS "Periodic Reports" with a suitable reporting rate. Many airline aircraft flying today are equipped with this capability. Where significant populations of such airline aircraft operate, consideration should be given to supporting this enhancement.

7.10.2 Enhancement(s): Implement RNP 1 Based Separation Reference: 6.5.4

7.10.2.1 RNP-1 can be based on position accuracy (ICAO, European Precision Area Navigation P-RNAV), or the containment concept (see 7.10.3, e.g. DO-236B, DO-283A, US SAAAR).

7.10.2.2 As the RNP level is reduced, navigation performance considerations: accuracy, availability, continuity, and integrity need to be fully accounted in separation safety analysis.

7.10.2.3 Ultimately, navigation integrity is based on the system's ability to achieve the target level of safety day in and day out, and is the result of integrated protection provided by airborne equipment, ATC infrastructure, procedure design, and other mitigation means, e.g. radar coverage.

7.10.2.4 Many new production business aviation and airline aircraft include containment-based RNP-1 capability. The remainder of new production aircraft and a significant portion of the existing airline and business aviation fleet are capable of basic (95% position accuracy) RNP-1 operations. These aircraft will require an aircraft systems (e.g. FMS) upgrade to support containment-based RNP-1 operations.

7.10.3 Enhancement(s): Implement Containment Based Separation Reference: 6.5.5

7.10.3.1 The concept of containment enables specific procedures and operations to be conducted with known target levels of safety. It allows smaller limits of protected airspace, contributing to lower aircraft separation values and for approaches, lower minimums. It is a prime enabler of the Free Flight concept of operation.

7.10.3.2 In addition to aircraft-based capabilities, e.g. certified RNP level, other factors such as traffic density, traffic mix, route complexity, air and ground communication and surveillance infrastructure such as radar coverage, ADS-C, CPDLC, and ADS-B are considered to define equipage requirements for a given target level of safety at a given location. As the RNP level is reduced, the separation safety analysis including communication and surveillance performance elements must be strengthened.

7.10.3.3 Communication requirements may be specified using the Required Communication Performance (RCP) concept. Limitations on today's communication systems, including spectrum exhaustion and the resulting frequency congestion, may force the introduction of new communication technologies. Due to the need for additional voice capacity in Europe and data capacity in both Europe and the U.S., many aircraft have already equipped with radios capable of 8.33 kHz channel spacing and/or VDL Mode 2 (VDLM2) capability. Until future requirements dictate the need for other technologies, 8.33 kHz and VDLM2 should be used wherever practical to take advantage of existing aircraft investments.

7.10.3.4 Surveillance requirements may be specified using the Required Surveillance Performance (RSP) concept. Where it is operationally advantageous to minimize aircraft separation, new capabilities including ADS-B and CDTI may be applied to improve surveillance performance.

7.10.3.5 In the integrated CNS/ATM system, separation can be based on CNS capabilities versus segregation of routes, and tactical separation can be transferred to the flight crew under certain situations.

Focus Area: ATM Service Effectiveness

7.11 Category: Provide Support to ATC Tasks 1

7.11.1 Enhancement(s): Use of SATCOM voice Reference: 6.5.8

7.11.1.1 The majority of business aircraft engaged in over-ocean/remote area operations are equipped for SATCOM voice. There is a strong desire on the part of the operators to take advantage this capability for routine (as well as emergency and non -routine, as currently permitted) communications. Work is in progress, and should be continued, to address the various issues involve including; performance, security, ground-initiated calls, costs and cost recovery etc. It is recognized that voice is not an alternative to data communications (CPDLC). In the interim, the use and global acceptance of SATCOM voice will improve safety, reduce communications workload, assist in relieving HF congestion and facilitate the regression of HF services.

7.11.2 Enhancement(s): Implement Data Link Applications Reference: 6.5.8

7.11.2.1 Communication data link and surveillance data link technologies and applications must be selected and harmonized for seamless global operations. FANS ADS-C, ADS-B (1090ES), and FANS-1/A CPDLC are in service in various regions of the world and ATN CPDLC is in service in Europe but lack global harmonization. Current regionalized initiatives, including utilizing unique message subsets and CPDLC procedures, will hinder efficient development and acceptance for global aircraft operations. Existing and emerging technologies should be implemented in a harmonized global manner, near term, to support long term goals. Harmonization will define global equipage requirements and therefore minimize user investment.

7.11.2.2 The use of air-ground data link applications for air traffic services (ATS) has been evolving for several years. Initial implementations have been Aircraft Communications Addressing and Reporting System (ACARS)-based. ACARS-based implementations continue to grow worldwide. FANS-1/A CPDLC and ADS, pre-departure clearance (PDC), departure clearances (DCL), and digital automatic terminal information system (D-ATIS) are the primary data link applications supported by ACARS-based ATS data link services. More recently, Aeronautical Telecommunication Network (ATN)-based implementations and broadcast-technology-based implementations have begun.

7.11.2.3 FANS-1/A and ATN applications support similar functionality, but with different avionics requirements. Many international airline aircraft have equipped with FANS-1/A avionics to take advantage of data link services offered in certain oceanic and remote regions. FANS-1/A equipage on international business aviation aircraft is underway and is expected to increase through the decade. Europe's Link2000+ program is driving initial equipage of ATN data link avionics, however, some participating States will accommodate FANS aircraft. This capability is expected to increase in European domestic airspace through the decade and possibly continue with US domestic airspace towards 2010 if the US CPDLC program is restarted.

7.11.2.4 ATN provides improved performance over FANS-1/A applications. It is uncertain whether aircraft capability will migrate toward ATN applications as ATN-based services are offered by more ANSPs. However, due to the large number of FANS-1/A capable aircraft, ANSPs must make provisions for the accommodation of FANS-1/A data link applications, provided the operational requirements can be supported by FANS-1/A performance.

7.11.2.5 VDL Mode-2 can be exploited by both FANS-1/A and ATN aircraft. Today there is a growing number of aircraft supporting legacy ACARS applications (including FANS-1/A) over VDL Mode-2. The use of VDL Mode-2 can significantly improve the communications performance available to FANS-1/A. This should also be considered by ANSPs when determining the adequacy of FANS-1/A for certain operations.

7.11.3 Enhancement(s): Improved Traffic Surveillance Capabilities Reference: 6.5.9.4

7.11.3.1 Current enhanced surveillance technologies such as ADS-C and ADS-B (1090ES) should be accepted as the near term and mid term global choice to improve and enhance ATM.

7.11.3.2 In support of this, it should be recognized that in remote and oceanic airspace where ADS-C is used, FANS capabilities exist on many air transport aircraft and could be added to business aircraft. ADS-B can be used to enhance traffic surveillance in domestic airspace, it should be noted that 1090ES is both available and should be accepted as the global choice for the ADS-B data link.

7.11.3.3 Introduction of a second data link adds to the complexity of the aircraft and ground equipment.

7.11.3.4 Universal Access Transceiver (UAT) link would require a new transponder added to the aircraft as well as additional ground equipment. Currently, UAT is being explored as a data link for ADS-B in the United States, but there is no guidance for certification or an existing plan for implementation except in specific, limited regions. UAT should only be considered for use in specific regional implementations, but only if appropriate, and is useful for proof of applications and validation of user benefits.

7.11.3.5 VDL-Mode 4 should not be used due to its complex nature, aircraft integration issues, and spectral inefficiencies.

7.12 Category: Improve Information Exchange

7.12.1 Enhancement(s): Standardize Flight Information Data Set Format

Reference: 6.5.11

7.12.1.1 A limited set of Flight Information Data is defined by the European Elementary and Enhanced Surveillance capabilities. This data is available from both FMS and certain non-FMS equipped aircraft via the Mode S transponder. Elementary Surveillance provides aircraft identification and minimum aircraft state data. Enhanced Surveillance adds additional aircraft state data.

7.12.1.2 An expanded set of Flight Information Data has been defined in support of the ADS-B capability. This data includes flight plan intent (trajectory) position integrity data. Aircraft are beginning to equip for transmitting ADS-B via Mode S extended squitter.

7.12.2 Enhancement(s): Implement Electronic Data Services Reference: 6.5.12

7.12.2.1 Electronic Data Services will support increased situational awareness by the flight crew via increased information on weather and terrain, in particular the airport surface. In most cases, benefits will require a cockpit display capable of presenting the electronic data to the flight crew along with a database and/or data link system capable of transmitting and storing the electronic data.

7.12.2.2 Many corporate and air carrier aircraft are capable of uplinking electronic data via VHF and/or Satellite-based ACARS systems. ACARS over VDL Mode 2 provides increased bandwidth that could be utilized if required for some graphical weather applications. In addition, commercial services offering aviation weather via a variety of media including satellite broadcast are emerging. A number of light General Aviation aircraft are equipping to access this capability.

7.12.2.3 The most recently certified new production aircraft include database and display capability which supports the storage and presentation of graphical charts, including airport surface maps. The vast majority of existing aircraft will require new or modified displays and database memory to provide this capability. An Electronic Flight Bag (EFB) is one method to add this capability; however the level of integration between the EFB and other aircraft systems will limit the operational benefits. EFBs and retrofit displays supporting Electronic Data Services are beginning to be installed on a limited number of corporate and air carrier aircraft.

7.12.2.4 In parallel with aircraft equipage, standards must be developed for efficiently defining, storing, and updating airport surface data and States must be encouraged to provide surface map data for their airports based on these standards. International and other primary airports should be targeted for the near term.

MEDIUM TERM ENHANCEMENTS

Focus Area: En-Route Efficiency

7.13 Category: Dynamic Airspace Management:

With the implementation of the Flexible Airspace Management and the Enhancement of the Route Flexibility Dynamic Airspace management can be implemented in the Medium term. Dynamic Airspace Management will require 3 enhancements: Integrated Decision Making, Demand Based Capacity and User Preferred Routes.

7.13.1 Enhancement(s): Integrated Decision Making
Reference: 6.3.9

7.13.1.1 Integrated Decision Making (IDM) will include airspace users in real time (e.g., in flight) decisions on access to airspace volumes. Aircraft Flight Management Systems will provide information on anticipated navigation performance and estimated time enroute for the proposed route change. The ability to uplink and downlink flight plans via CPDLC will support IDM. Optimal benefit of this can be realized when the CPDLC function is integrated with the aircraft FMS such as is the case with FANS-1/A aircraft.

7.13.2 Enhancement(s): Demand-Based Capacity
Reference: 6.3.10

7.13.2.1 New technology in advanced data link and Enhanced Surveillance should be fully exploited to further implement a more dynamic management of airspace.

7.13.3 Enhancement(s): User-Preferred Routes
Reference: 6.3.11

7.13.3.1 User-Preferred Routes are an enhancement of Dynamic route management, as it provides additional strategic user-preferred route planning capabilities. User-Preferred routing requests will be generated by the airspace user or their dispatch functions, and submitted to the ANSP for approval or renegotiation if a conflict is determined followed by their transmission to aircraft. Advanced scenarios would have the aircraft making requests directly to ANSPs who would process and modify the request if necessary and then forward the approved route to aircraft.

7.13.3.2 Capabilities supporting this enhancement are defined in section 7.5.3.

Focus Area: TMA/Airport Efficiency/Capacity

7.14 Category: Implement Dynamic TMA Management

7.14.1 Enhancement: Automated Tools for Arrival and Departure Sequencing
Reference: 6.4.10

7.14.1.1 Some aircraft capabilities will support enhanced arrival and departure sequencing with data link of computed aircraft performance data and possible inclusion of climb and descent schedules with filed flight plans. Also, aircraft certification to lower minimums (e.g., FMSs supporting lower RNP or CAT III operations) will further the objective of these tools by increasing operational reliability and predictability.

7.14.2 Enhancement: Dynamic Wake Vortex Detection and Mitigation
Reference: 6.4.11

7.14.2.1 Wake vortex mitigation constraints based on aircraft separation requirements may be improved through implementation enhanced surveillance capabilities to improve airspace capacity. Additional enhancements in reducing aircraft spacing can be achieved by managing an aircraft's predicted performance and implementing variable vertical path approaches. Variable vertical paths will allow for the heaviest aircraft category to utilize the shallowest angle while lighter aircraft categories would use a steeper angle to stay above the preceding aircraft's wake vortex. These variable vertical path approaches could utilize RNP-.3 (or lower) LNAV/VNAV approach design.

7.14.3 Enhancement: Collaborative Capacity Management
Reference: 6.4.12

7.14.3.1 Modern aircraft equipped with ACARS, Weather real time information data link and certified to lower minima can provide timely information to the ATM and be used to reduce a significant number of disruptive events. Airborne FMS RTA capability as described in 7.4.3.2 can support the collaborative capacity management concept. Modified flight plans may be uplinked via CPDLC. Optimal benefit of this can be realized when the CPDLC function is integrated with the aircraft FMS.

7.15 Category: Integrated TMA/Airport Management

7.15.1 Enhancement: Dynamic Management of TMAs.
Reference: 6.4.13

7.15.1.1 Many existing aircraft and all new production aircraft have flight management or navigation systems capable of storing standard arrival and departure routes for selection and activation by the pilot. These routes must be pre-defined and included in the scheduled database updates (i.e. 28 day AIRAC cycle).

7.15.1.2 The key to this benefit is the ability to load constraints and clearances dynamically into the FMS. This capability will require a high performance data link system that is integrated with the aircraft FMS. Current data link error-checking methods do not provide error correction although they do ensure that the received message is accurate. Emerging ATN data link capability will provide the level of performance necessary for the uplink of terminal area route changes. However, initial aircraft applications of ATN capability are generally not integrated with the FMS (uplink messages are isolated in the Communication Management Unit). Further updates to provide this integration will be needed to support dynamic route changes in the TMA.

7.15.2 Enhancement: Match IMC and VMC Operating Capacity Reference: 6.4.14

7.15.2.1 During IMC, a significant capacity loss often results from the elimination of certain runway ends due to instrument approach procedures with high minimums. Many aircraft today are capable of RNAV operations and RNP capability supported by GPS and other high integrity navigation sensors is increasing. RNAV and RNP capability can support approach procedures with lower minimums commensurate with available external visual references without installing expensive ILS ground equipment. Exploiting this capability may extend VMC capacity to near Category I visibility.

7.15.2.2 GPS Landing System (GLS) airborne capability based on Ground-Based Augmentation System (GBAS) ground systems is in development. At maturity, this capability is expected to support Category III operations with more flexibility and at lower cost than with ILS and MLS commensurate with available external visual reference. This capability will support further increases in IMC operating capacity.

7.15.2.3 An increasing number of air transport and business aviation aircraft are equipping with Head-Up Displays (HUD). In some applications, these displays are augmented with Enhanced Vision System (EVS) sensor data. HUDs with EVS and other emerging display enhancements can provide much improved surface awareness leading to safer and more efficient runway and taxiway operations, enhancing IMC capacity.

7.15.2.4 New procedures are being developed based on RNP capability to maintain throughput on closely spaced parallel runways in reduced visibility. These benefits will be increased in the future through the use of ADS-B and CDTI.

Focus Area: En-Route Capacity

7.16 Category: Collaborative Separation 1

7.16.1 Enhancement: ASAS 1 Applications Reference: 6.5.7

7.16.1.1 ASAS and the situational awareness it provides is primarily dependent upon ADS-B and/or TIS-B. The internationally accepted communication link for ADS-B and TIS-B data is 1090ES. 1090ES transmit is an advanced capability of a Mode S transponder. Most new production transponders are capable of 1090ES operation and many existing transponders can be upgraded to provide this capability.

7.16.1.2 Receipt of 1090ES data (ADS-B or TIS-B) is normally a function of the TCAS (ACAS) computer. The ADS-B and TIS-B data is processed by the TCAS computer for display as part of a Cockpit Display of Traffic Information (CDTI) function. While this capability has been demonstrated in a number of trial programs, few production systems currently support it.

7.16.1.3 Early ASAS applications based solely on CDTI will support enhanced situational awareness (see and avoid) and improved ability to maintain desired aircraft separation. Future software algorithms will provide additional information to the pilots to support station-keeping operations in the medium-term and self-separation in the long-term.

Focus Area: ATM Service Effectiveness

7.17 Category: Provide Support to ATC Tasks 2

7.17.1 Enhancement: Tactical Utilization of Aircraft Intent Data Reference: 6.5.10.2

7.17.1.1 Aircraft flight plan intent data (4-D trajectory information including next and 'next-next' waypoints) is part of the ADS-B transmission. European requirements for 'Enhanced Surveillance' and Australian ADS-B-based surveillance capability are creating opportunities for aircraft upgrades to provide ADS-B out capability.

7.17.1.2 Aircraft intent data can be used initially by controllers, but as more aircraft are equipped with ADS-B receive capability, the flight crew will be able to use this information to participate in separation management.

7.17.2 Enhancement: Tactical Redistribution of Workload Reference: 6.5.10.3

7.17.2.1 In some low density (e.g., oceanic) airspace, ACAS information has been used to temporarily assign separation responsibility to the flight crew for tactical operations (e.g., in-trail climb or descent and passing maneuvers). As ASAS capability is introduced in aircraft, the additional information (e.g., aircraft identification and intent) available to the pilot will allow this tactical separation delegation to occur in higher density environments, including terminal areas.

7.17.3 Enhancement: Separation Delegation Scenarios Reference: 6.5.6

7.17.3.1 See 7.17.2.1 for description of capabilities supporting initial tactical separation delegation. In the longer term, with more capable, higher integrity airborne algorithms, strategic separation delegation to the flight crew will be possible (see 7.16.1). Initial self-separation will occur in enroute operations, with terminal area applications to follow.

8. Conclusions and Recommendations

8.1 General

The conclusions and recommendations of this report result from the assessment by the Joint Committee tasked with developing the business aviation position for the implementation of CNS/ATM systems. The objective is a cost effective, secure, safe, and harmonized global air navigation plan providing a system that is equally available to all airspace users.

The conclusions of the Joint Committee were derived from the roadmap and from other sections of this report. The conclusions are presented for communications, navigation, surveillance, and system integration.

The overall intent of the recommendations is to promote safety, equitable airspace access, efficiency and harmonization. In order to achieve these objectives, the recommendations are addressed to the Business Aviation Operators, ANSPs, ICAO, and the Airframe and Avionics Manufacturers. The tables in this section summarize the Joint Committee recommendations.

The Joint Committee also recommended to its respective parent Associations that it should reconvene within 2 to 3 years to review the progress of the aviation community in providing CNS/ATM improvements and update the report and roadmap.

8.2 Communications Conclusions

1. ANSPs and aircraft operators will implement data link communications in support of safety, efficiency, and capacity enhancements.
2. Use of data link technology will be required to support User Preferred Routes (both ANSP and Operators).
3. Broadcast services (e.g. 1090ES ADS-B) will be used (e.g. to enhance situational awareness).
4. 8.33 kHz channel spacing will be used wherever practical to take advantage of existing aircraft investments in the near term to support increased voice capacity (e.g. in Europe). However, 8.33 kHz is not desired for implementation outside of Europe and not endorsed by operators as a long-term solution. The aviation community should work towards a harmonized technical solution.
5. Data link (VDLM2) will be used to take advantage of existing aircraft operators, ANSP, Communication Service Provider investments and pursuant to industry decisions. This will provide a means for increasing data capacity.
6. There is a lack of alignment among data link technologies. Currently there are FANS-1/A ADS and CPDLC implementations around the world. In addition, there are ATN CPDLC implementations (e.g. Link2000+). Every effort should be made to ensure global harmonization of these activities.
7. ATN provides improved performance over FANS-1/A. It is uncertain whether aircraft equipped with FANS-1/A capability will timely migrate toward ATN as ATN-based services are offered by more ANSPs.
8. ANSPs must make provisions for the accommodation of FANS-1/A CPDLC and ADS data link applications, provided the operational requirements can be supported by FANS-1/A performance.

9. Benefits will accrue to operators and ANSPs in the event that SATCOM voice can be accepted as an alternative to HF voice as a primary means of communication.
10. Greatest benefits will accrue when direct pilot controller communications are available in all environments.

8.3 Navigation Conclusions

1. Continued implementation of Reduced Vertical Separation Minima above FL290 will increase system Vertical Capacity and improve efficiency in geographic areas not presently utilizing RVSM.
2. Non-SI unit, feet, to remain as the ICAO permitted unit of measurement for height /altitude designation. Harmonization of procedures is needed for the transition between adjacent States which do not both utilize the same unit of measurement. States utilizing SI unit (i.e. metric) flight levels need to conform with the ICAO Table of Metric Cruising levels.
3. Future navigation applications will be based on performance standards and metrics, known as Required Navigation Performance (RNP). A combination of technologies based on space, ground, and aircraft based systems will be required to meet various levels of RNP.
4. Containment-capable systems are currently being introduced on some new production business aircraft. Containment-based RNP-4, in combination with FANS-1/A CPDLC and ADS-C, supports 30/30 nm separation.
5. Most existing business aircraft will require an aircraft systems' (including FMS) upgrade to support containment-based operations.
6. WGS 84 is the foundation for GPS, Galileo, and some surveillance functions. Currently it is not always the basis of state defined source data for aircraft navigation data bases. The lack of implementation by States of the ICAO Annex 15 Standard (effective 1 January 1998) is constraining the use of currently available aircraft capabilities and can otherwise pose a threat to safe operations.
7. RNAV/RNP approaches for runways served by business aircraft will improve accessibility, operating minima and safety.

8.4 Surveillance Conclusions

1. ANSPs and aircraft operators will implement data link communications in support of safety, efficiency, and capacity enhancements.
2. Use of data link technology will be required to support User Preferred Routes (both ANSP and Operators).
3. Broadcast services (e.g. 1090ES ADS-B) will be used (e.g. to enhance situational awareness).
4. Currently there are FANS-1/A ADS implementations around the world. Every effort should be made to ensure global harmonization of procedures.
5. 1090ES is available and should be accepted as the global choice for the ADS-B data link.
6. 1090ES ADS-B and cockpit display of traffic information (CDTI) can be used to ease radio congestion and enhance ground situation awareness. In addition, Head-Up Displays (HUD) and Enhanced Vision Systems (EVS) can provide improved awareness of terrain and the airport environment under low visibility conditions, leading to enhanced safety and airport efficiency.
7. WGS 84 is the foundation for GPS, Galileo, and some surveillance functions. Currently it is not always the basis of state defined source data for aircraft navigation data bases. The lack of implementation by States of the ICAO

Annex 15 Standard (effective 1 January 1998) is constraining the use of currently available aircraft capabilities and can otherwise pose a threat to safe operations.

8.5 System Integration Conclusions

As the ATM environment evolves, CDM will be increasingly applied to better manage highly congested airspace and airports. In the process, it is important that automated mechanisms similar to those used by airlines be established for the business aviation community to adequately participate. In particular, the unscheduled nature of business aviation operations will have a significant impact on the success or failure of a CDM-generated solution. At the same time, to ensure fair and equitable distribution of airspace system capacity, all user requirements, including those of business aviation, must be factored into the CDM process. Potential mechanisms for business aviation do exist and are encouraged.

8.6 Recommendations

International Civil Aviation Organization

Communications	Navigation	Surveillance	System Integration
• Advocate that Regional Planning Groups establish realistic and coordinated implementation schedules that consider the needs of all classes of users • Advocate that ANSPs harmonize on CPDLC message set and procedures • Update Regional Supplementary Procedures (Doc 7030) to accommodate use of SATCOM voice for routine oceanic/remote communications in all regions • Simplify and rationalize regulatory processes for operational approvals	• Advocate that Regional Planning Groups establish realistic and coordinated implementation schedules that consider the needs of all classes of users • Renew initiatives to promote WGS-84 implementation by all States • Simplify and rationalize regulatory processes for operational approvals (RVSM, RNP, etc.) • Strengthen procedures for transition between FIRs using feet and metres. • Stress the need for certain States to implement ICAO standards in FIRs using metric units for flight levels • Urge implementation of RNAV/RNP terminal area and approach procedures including airports utilized by business aviation	• Advocate that Regional Planning Groups establish realistic and coordinated implementation schedules that consider the needs of all classes of users • Advocate that ANSPs provide ADS-B using 1090ES • Urge use of FANS ADS-C for enhanced surveillance in oceanic/remote airspace	• Advocate that Regional Planning Groups establish realistic and coordinated implementation schedules that consider the needs of all classes of users

Air Navigation Service Providers

<table>
<tr><th>Communications</th><th>Navigation</th><th>Surveillance</th><th>System Integration</th></tr>
<tr>
<td>Voice
Do not implement 8.33 kHz except in Europe
Accept and expand the use of SATCOM voice for routine oceanic /remote communications
Data link (CPDLC)
Develop plans to accommodate both FANS CPDLC and ATN CPDLC where feasibility while ensuring transparent and consistent operations in all regions
Harmonize on CPDLC message set and procedures
Implement data link for other ATS services (e.g. DLC, D-ATIS, OCL)</td>
<td>Implement WGS-84
Strengthen procedures for transition between FIRs feet and metres.
States using metric units for flight levels are urged to implement ICAO standards
Implement RNAV/RNP terminal area and approach procedures including airports utilized by business aviation
Develop, in consultation with users, plans to phase out obsolete ground-based navigation facilities</td>
<td>Utilize 1090ES for ADS-B communication (refrain from imposing additional data link technologies)
Migrate from time based to distance based separation in oceanic/remote areas
Consider alternatives to radar such as multilateration to enhance safety using existing on-board avionics
Utilize FANS ADS-C for enhanced surveillance in oceanic/remote airspace</td>
<td>Integrate CDM processes to accommodate business operators
Develop integrated decision making system/procedures to enable real-time flight plan updates to enhance enroute and terminal area efficiency</td>
</tr>
</table>

Business Aviation Operators

<table>
<tr><th>Communications</th><th>Navigation</th><th>Surveillance</th><th>System Integration</th></tr>
<tr>
<td>Voice
Continue to provision 8.33 kHz only to support European operations
Expand participation in NAT or other SATCOM voice programs
Data link
Implement FANS CPDLC capability on aircraft for frequent oceanic/remote operations to enhance safety and preserve airspace access
Implement ATN CPDLC capability as appropriate (i.e. Link2000+) on European domestic aircraft when sufficient benefits are established
Utilize data link for other ATS services (e.g. DCL, D-ATIS, OCL)
Ensure timely and effective flight crew training is implemented for data link communication systems</td>
<td>Aircraft/FMS Upgrade
Install containment based RNP capability
Install RTA capability as needed to support optimized arrival procedures or similar enhancements in air operations
Advocate the development of RNAV/RNP terminal area procedures
Ensure timely and effective flight crew training is implemented for navigation systems</td>
<td>Mode S
Install Elementary Surveillance capability to support operations where required
Install Enhanced Surveillance capability to accommodate European mandate (2007), or when waivers are no longer available
Install 1090ES on new aircraft for ADS-B and retro-fit on an opportunistic basis
Data link (ADS-C)
Implement FANS capability on aircraft for oceanic/remote operations to enhance safety and preserve airspace access
Ensure timely and effective flight crew training is implemented for surveillance systems</td>
<td>Explore opportunities to achieve CDM participation
Consider equipage with systems that enhance situational awareness (e.g. graphical weather, HUD and EVS)</td>
</tr>
</table>

Airframe and Avionics Manufacturers

Communications	Navigation	Surveillance	System Integration
Ensure timely availability of: • engineering, documentation, and/or STCs/SBs to support new aircraft deliveries and system upgrades on existing aircraft • training and associated documentation.	Ensure timely availability of: • engineering, documentation, and/or STCs/SBs to support new aircraft deliveries and system upgrades on existing aircraft • training and associated documentation.	Ensure timely availability of: • engineering, documentation, and/or STCs/SBs to support new aircraft deliveries and system upgrades on existing aircraft • training and associated documentation.	• Integrate CNS functionality within aircraft/ground architectures to ensure operational and cost effective solutions

Industry Organizations (IBAC, GAMA, etc.)

Communications	Navigation	Surveillance	System Integration
• Revisit roadmap and JC conclusions and recommendations in 2 to 3 years	• Revisit roadmap and JC conclusions and recommendations in 2 to 3 years	• Revisit roadmap and JC conclusions and recommendations in 2 to 3 years	• Revisit roadmap and JC conclusions and recommendations in 2 to 3 years

IBAC/GAMA CNS/ATM Joint Committee (CNS/ATM JC/1)

NBAA HQ
Washington, D.C.
19-20 August 2004

Terms of Reference for a **Appendix A**

Joint Committee of Business Aviation Operators and Manufacturing Industries on Development of a Strategy and Plan to integrate Business Aviation into the global implementation and operation of CNS/ATM

Purpose

These Terms of Reference describe the background, scope, objectives and management structure for a joint operational and technical committee tasked with development of a strategy and plan for the introduction of evolving CNS/ATM systems by business aviation.

Background

In the 1980s, ICAO, Member States, service providers and the aviation user community started work on development of a new plan for managing the world's airspace and navigation systems, taking into account the new emerging technologies. It was recognized that the existing approach to provision of air traffic services and aircraft navigation were limiting capacity and efficiency.

The task of exploring a new dynamic was assigned in 1983 to an ICAO Special Committee on the Future Air Navigation System (FANS), in which IBAC participated. The FANS work culminated in the ICAO 10th Air Navigation Conference in 1991, where the FANS concept was endorsed.

Following acceptance by the ICAO Council, FANS was subsequently renamed the Communications, Navigation, Surveillance/ Air Traffic Management (CNS/ATM) concept. Implementation of CNS/ATM was initially planned through a 'Global Co-ordinated Plan for transition to ICAO CNS/ATM Systems'. Later, with maturation of the concept, a Global Air Navigation Plan for CNS/ATM was developed.

In the intervening years it became evident that in order to ensure better use of CNS/ATM technologies and to ensure coordinated implementation, an Operational Concept was needed. The ICAO Air Traffic Management Operational Concept Panel (ATMCP) was formed to develop the Operational Concept, which was produced and then sanctioned by the 11th Air Navigation Conference held in September 2003. Work is continuing on development of Standards and Recommended Practices that will govern new equipment in the future.

In parallel with this activity and based on Required Navigation Performance (RNP), material was developed and introduced into ICAO PANS ATM (Doc 4444) to accommodate reductions in horizontal separation criteria. Work continues in this field by the ICAO SAS Panel (formerly the RGCS Panel).

Separation based on RNP10 has been implemented in a number of ICAO Regions, including AS/PAC and MID. Further reductions in horizontal separation based on RNP 4 are under consideration in several Regions, including the NAT. Such further reductions will require direct pilot controller communication using data link.

In addition to the adoption of technical characteristics for a number of air-ground 'links', specifications have also been adopted for ADS and CPDLC message sets and related operational procedures. Work continues under the ICAO OPLINK Panel (formerly the ADS Panel).

The CNS/ ATM operational concept covers a large range of institutional, infrastructural, procedural and technological issues. Technology issues apply to many new systems such as GNSS, ADS/B, CPDLC, datalink and other emerging systems.

It has become clear through the years of development of the various CNS/ATM plans that the airline industry has been the primary user focal point for technological and procedural development. The airline industry has been extremely active and engaged in planning activities and contributing to work by ICAO and service providers. The business aviation industry has been very active at discussions at the high level, and has presented various papers on the impact of CNS/ATM to business aviation operations. However, since the business aviation industry lacks a cohesive technological planning mechanism, the business aviation industry has not been able to significantly influence the specific planning forums dealing with technologies and procedures.

The business aviation industry is very diverse, with a wide spectrum of manufacturers (as opposed to the two very large manufacturers in the airline industry). Operators are generally small and lack the R&D staff to develop new concepts. With over 14,000 operating companies, business aviation is very significant in numbers, but given the horizontal shape of the industry it is very difficult to coordinate harmonized statements of requirements.

Generally, business aviation has lacked a mechanism to provide leadership in developing a clear statement of operational requirement. Aircraft manufacturers have been looking to the operators to define their requirements; yet operators generally do not have the critical mass in terms of expertise and available staff to provide the input.

A mechanism is recommended herein to develop coordinated input from business aviation for CNS/ATM plans and input to Standards and Recommended Practices. A Joint Committee of the Operators and Manufacturing Industries is proposed to develop a Business Aviation CNS/ATM Operational Plan.

Objectives

The objectives of the Joint Committee are to:

Review the forecasts of business aviation fleet in 15 years;

- ✓ Research development programs of service providers such as the FAA, NAVCAN, JPDO, etc

- ✓ Assess ICAO data link technical SARPs
- ✓ Review emerging CNS/ATM technologies;
- ✓ Review ICAO CNS/ATM Global Plan
- ✓ consider evolving Regional implementations and plans
- ✓ Review the CNS/ATM Operational Concept
- ✓ Develop cost/benefits and transition scenarios for various options;
- ✓ Develop options for a harmonized business aviation position;
- ✓ Develop a strategy and plan to integrate business aviation into the evolving CNS/ATM implementation and RNP operations in;
  1) oceanic and remote airspace, and
  2) continental airspace

Scope

The Joint Committee is to develop a more detailed action plan during the first series of meetings and will propose changes to the Terms of Reference as required.

The Joint Committee will address both oceanic (and remote) and continental operations applicable to the full range of business aircraft sizes. Initially it is proposed that the Joint Committee consider all elements of the CNS/ATM Operational Concept as it relates to technologies in the cockpit. In so doing, the JC is expected to recommend an appropriate balance of attention to the near-to-intermediate term related to evolving CNS/ATM implementation and the longer term involving the transition towards and realization of the CNS/ATM Operational Concept.

Secondly, the JC should consider other aspects related to airspace organization and management, aerodrome operations, demand and capacity balancing and traffic synchronization & coordination be assessed to determine if a business aviation position could be of benefit.

Membership

The Joint Committee should consist of representatives from:

- ✓ business aircraft operators;
- ✓ aircraft manufacturers;
- ✓ avionics manufacturers;
- ✓ service providers;
- ✓ business aviation associations.

Advisers to the Committee may be invited from research establishments and other bodies, as appropriate.

Management

A Steering Committee will provide overall authority for the project. The Steering Committee will be co-chaired by the Interim President of GAMA and the IBAC Director General. Members of the Steering Committee will be appointed representatives from GAMA and IBAC and will include the

Project Manager. The Steering Committee will make final decisions regarding the submission to ICAO and will be the approving authority for the final report of the JC.

The Terms of Reference will be developed and approved by the Steering Committee with full input from the Joint Committee Members.

A Project Manager will have the following responsibilities:

1. Plan and organize meetings of the Joint Committee.
2. Chair meetings of the JC.
3. Research and coordinate material for consideration of the JC.
4. Liaise as required with various information sources.
5. Develop draft report and brief the JC
6. Finalize report based on agreements reached by the JC.

The JC will make decisions as much as possible through consensus.

Deliverables

The Joint Committee is to develop a report that outlines the consolidated recommendations of the business aviation operators and equipment and airframe manufacturers for the development of a detailed plan for CNS/ATM implementation.

Meetings

Meetings will be organized by the Project Manager with support from the contributing organizations. It is expected that approximately 4 to 6 meetings will be required to develop the draft Implementation Concept.

Schedule

The target completion date for the Final Report is April 29, 2005.

Costs

Expenses of Members of the Joint Committee will be born by their respective organizations or companies. Costs for the Project manager will be born by IBAC, with any assistance from contributing organizations as required. IBAC will fund administrative costs for the Joint Committee such as meeting rooms.

The Project Manager will develop cost estimates following the first full meeting of the Joint Committee.

List of JC Members, Meetings Conducted, and Presenters

Arriel, Antonio	DAC Brazil
Benich, Chris	Honeywell Aerospace
Braga, F.	DECEA Brazil
Brown, Steve	National Business Aviation Association (NBAA)
Byrum, Jim	Cessna Aircraft Company
Conyers, Robert	Global Aerospace
Fancy, Thomas	Gulfstream Aerospace Corp
Febeliano, Adalberto	ABAG - Associação Brasileira de Aviação Geral
Hamel, Christophe	Honeywell Aerospace
Hennig, Jens C.	GAMA - General Aviation Manufacturers Association
Ingleton, Peter	International Business Aviation Council, Ltd. (IBAC)
Kearns, Kathy	SITA
Lamond, Robert G.,(Bob)	National Business Aviation Association (NBAA)
Lucena, A.	DAC Brazil
Maiolla, Vaughn	SITA
Mann, David F.	CBAA/Canadian Pacific Railway
Nagowski, Victor J.	Aeronautical Radio Inc. (ARINC)
Ramos, Calvin T.	NASA Glenn Research Center
Rizzo, Marco	Embraer
Sheldon, Sean	Gulfstream Aerospace Corporation
Spruston, Donald D.	International Business Aviation Council, Ltd. (IBAC)
Stine, Bill	National Business Aviation Association (NBAA)
Stohr, Dave	Air Training International
Swanda, Ron	GAMA General Aviation Manufacturers Association
Valle, Marc	Dassault FalconJet Corp.
Weight, Ron	Honeywell International
Wu, David	Rockwell Collins

JC Meetings

JC/1	August 19-20, 2004	Washington, DC
JC/2	November 8-10, 2004	Annapolis, MD
JC/3	January 18-20, 2005	Brussels, Belgium
JC/4	March 7-9, 2005	Montreal, Canada
JC/5	April 11-12, 2005	Washington, DC

Presenters (JC/2 and JC/3 meetings)

Mr. V. Galotti, ICAO

Mr. D. Watrous, RTCA

Mr. A. Dumsa, IATA

Mr. P. Ingleton, IBAC on behalf of Mr. D. Harris, Nav Canada

Mr. C. Ramos, NASA

Mr. C. Benich, Honeywell Aerospace

Mr. D. Wu, Rockwell Collins

Mr. M. Valle, Dassault Falconjet

Mr. J. Byrum, Cessna Aircraft Company

Mr. M. Rizzo, Embraer

Ms. K. Kearns, SITA

Mr. A. Anderegg, FAA Joint Planning and Development Office (JPDO)

Mr. P. Grogan, ARINC

Mr. R. Jehlen, FAA

Mr. D. Harris, Nav Canada

Mr. P. Renaud, Eurocontrol (in lieu of Mr. D. Young)

Appendix C

List of Acronyms

A-SMGCS	Advanced Surface Movement Guidance and Control System
ABAG	Associação Brasileira de Aviação Geral
ACARS	Aircraft Communications Addressing & Reporting System
ACAS II	Airborne Collision Avoidance System
ADS-A	Automatic Dependent Surveillance – Addressed (aka ADS-C)
ADS-B	Automatic Dependent Surveillance - Broadcast
ADS-C	Automatic Dependent Surveillance - Contract (aka ADS-A)
AIRAC	Aeronautical Information Regulation And Control
ANSP	Air Navigation Service Provider
AO	Aerodrome Operations
AOC	Aeronautical Operational Control
AOM	Airspace Organization and Management
ARINC	Aeronautical Radio, Inc.
ASAS	Airborne Separation Assistance System
ATC	Air Traffic Control
ATFM	Air Traffic Flow Management
ATM	Air Traffic Management
ATMCP	Air Traffic Management Concept Panel (ICAO)
ATN	Aeronautical Telecommunications Network
ATS	Air Traffic Services
AUO	Airspace User Operations
B-RNAV	Basic Area Navigation
CBAA	Canadian Business Aviation Association
CDM	Collaborative Decision Making
CDTI	Cockpit Display of Traffic Information
CM	Conflict Management
CNS	Communication, Navigation, and Surveillance
CDA	Continuous Descent Arrival/Approach procedures
CDARR	Continuous Descent Arrival
CDAPP	Continuous Descent Approach
CDFA	Continuous Descent Final Approach
CDM	Collaborative Decision Making
CDU	Control Display Unit
CPDLC	Controller Pilot Data Link Communication (both FANS and ATN based)
DARP	Dynamic Airborne Rerouting Program
D-ATIS	Digital Automated Terminal Information Service
DCB	Demand and Capacity Balancing
DCL	Departure CLearance
DME	Distance Measuring Equipment
DST	Decision Support Tool
EDS	Electronic Data Services
EFB	Electronic Flight Bag
EFVS	Enhanced Flight Vision System
EGNOS	European Geostationary Navigation Overlay Service
EVS	Enhanced Vision System
FANS-1/A	Future Air Navigation System-Boeing/Airbus
FBO	Fixed Base Operator
FIR	Flight Information Region
FMS	Flight Management System
FUA	Flexible Use Airspace
GAMA	General Aviation Manufacturers Association
GBAS	Ground Based Augmentation System

GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HF	High Frequency
HUD	Head Up Display
IATA	International Air Transport Association
IBAC	International Business Aviation Council
ICAO	International Civil Aviation Organization
IDM	Integrated Decision Making
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
JPDO	Joint Planning and Development Office
KPI	Key Performance Indicators
LAAS	Local Area Augmentation System
LNAV	Lateral NAVigation
MCDU	Multifunction Control Display Unit
Mid-Term	Baseline Period Starting in 2010
MSAS	MTSAT Satellite Augmentation System (Japan)
NBAA	National Business Aviation Association
OAG	Official Airline Guide
OCD	Operational Concept Document
OCL	Oceanic CLearance
OEM	Original Equipment Manufacturer
PDC	Pre-Departure Clearance
PRM	Precision Runway Monitor
P-RNAV	Precision Area Navigation
RASP	Required ATM System Performance
RCP	Required Communication Performance
RET	Rapid Exit Taxiway
RNP-x	Required Navigation Performance (degree of accuracy (ICAO terminology) or containment (FAA/Eurocontrol terminology) in nm)
RNAV	Area Navigation
ROT	Runway Occupancy Time
RSP	Required Surveillance Performance
RTA	Required Time of Arrival
RTSP	Required Total System Performance
RVSM	Reduced Vertical Separation Minima
SAAAR	Special Aircraft & Aircrew Authorization Required
SARPS	Standards and Recommended Practices (ICAO Documents)
SATCOM	Satellite Communications
SB	Service Bulletin
SBAS	Satellite Based Augmentation System
SDM	Service Delivery Management
Short Term	Baseline Period Starting in 2005
SI	Système International d'Unités
SID	Standard Instrument Departure
SITA	Societe Internationale de Telecommunications Aeronautiques
STAR	Standard Terminal Arrival Route
STC	Supplemental Type Certificate
SVS	Synthetic Vision System
SWIM	System Wide Information Management
TAP	Tailored Arrival Procedure
TAWS	Terrain Awareness and Warning System
TCAS	Traffic alerting and Collision Avoidance System
TIS-B	Traffic Information System Broadcast
TMA	TerMinal Area
TMA	Traffic Management Advisor

TS	Traffic Synchronization
UAT	Universal Access Transceiver
UAV	Unmanned Air Vehicle
UPR	User Preferred Route
VFR	Visual Flight Rules
VHF	Very High Frequency
VDL Mx	VHF Digital Link Mode 2,4
VMC	Visual Meteorological Conditions
VNAV	Vertical NAVigation
VOR	VHF Omnidirectional Range
VPN	Virtual Private Networks
WAAS	Wide Area Augmentation System

Summary Matrix of Major Characteristics of Various Concepts of Operations Documents

This appendix contains a matrix of information from the RTCA Concepts of Operations, the ICAO Global ATM Concept of Operations and the European Air Traffic Management for the Year 2000+ documents. The information from these various documents reflect characteristics of a future ATM system that are supportive of business aviation.

The RTCA Concept of Operations identifies an evolution of capabilities to continue and improve United States National Airspace System safety and efficiency well into the 21st century. The concepts in the full document are presented from environmental, airspace user and service provider perspectives.

The environmental perspective provides a general description of expected technological and procedural changes. The user perspective describes these changes as well as adjustments in roles for the user. Similarly, the service provider perspective describes how the role of the service provider evolves. The document also describes NAS evolution in terms of three periods; near term (up to 2005), mid term (2005-2010), and far term (beyond 2010).

The expanded use of advanced information technology, automation, and collaboration in NAS modernization provides increased airspace capacity, improved aviation safety, and enhanced operational efficiency for aircraft operators and service providers.

The first section provides a broad description of the six major concept areas: (1) NAS Management (Strategic Flow and Resource Management), (2) Flight Planning and Emergency Alerting Services, (3) Surface, (4) Arrival/Departure, (5) Enroute, and (6) International Oceanic. The second section extracts specific, detailed concepts and/or capabilities pertinent to business aviation from the particular “Environment, User Perspective, and/or Service Provider Perspective” areas of the major concepts described above.

Several “User Perspective” sub-sections of the major concept areas are divided into “Civil Users With/Without FOC Capability.” FOCs (Flight Operations Centers) are defined as either an integral control function within the direct control of the flight department itself or an outside facility such as a major flight planning service provider that performs all the same functions of an internal FOC. In order to fully take advantage of the technology coming down the road aircraft will have to be tied to an FOC as opposed to remaining “independent operators” in the NAS.

The third section of the spreadsheet explains the System Wide Information Management (SWIM) concept which is integral to several of the operational concepts contained within the document.

The fourth and fifth sections of the matrix contain extracts from the ICAO and EATM documents. Again, only the major characteristics seen as desirable for business aviation in a future ATM system were extracted from these documents.

RTCA Concept Of Operations Document	
Major Concept Area	**Broad Description**
NAS Management (Strategic Flow and Resource Management)	Comprehensive information exchange to improve flight planning and anticipate changes in capacity and traffic conditions. Planning and execution of strategic flow initiatives carried out using decision support tools with automatic exchange of results. Demand and capacity managed by allocating access to resources, collaborative rerouting and realignment of sectors and associated resources.
Flight Planning and Emergency Alerting Services	Flight Deck, Flight Ops Center and Service Providers have interactive flight planning capabilities using real time data. Controlled times of arrival are primary method for regulating flows. Requests and counter proposals are auto-negotiated/updated in both planning and airborne phases of flight. Intelligent Agents, computational systems operating autonomously, compare system changes to known user and service provider objectives and provide best alternatives to decision makers. Aircraft have enhanced locator transmitters that utilize discrete codes and satellite navigation positioning to aid in search and rescue
Surface	Data link provides route of flight clearances, airport information, positions of other aircraft, taxi routes, and weather conditions on a significantly wide spread basis. Voice communication in use only for unequipped and as backup. Departure and arrival runway assignments based on surface automation's prediction of congestion and related taxi plan. For departures, taxi time updates and associated estimates included in the taxi plan are coordinated automatically with airspace automation to efficiently sequence ground traffic to match projected traffic flows aloft. Total airport surface surveillance provides all stakeholders with aircraft and vehicle location information. This coupled with enhanced navigation provides for zero-visibility operations.
Arrival/Departure	Aircraft operate along optimum profiles in the transition to and from the airport. Satellite navigation with vertical guidance makes it possible to provide precision instrument approaches and departures at practically any landing facility. Pilots monitor these paths on a moving map display. Modifications to service provider procedures and improvements in turbulence and wake vortex avoidance facilitate a reduction in separation standards. CTA is routinely used. Dynamic airspace management matches traffic volume to multiple enhanced navigation arrival and departure routes. Enhanced all weather landing systems allow fro multiple paths to final approach to facilitate full use of runway capacity. Virtual vision devices on flight decks enable more "visual like" operations regardless of weather conditions.
Enroute	DSS's such as conflict probe, resolution advisor, and automatic trial planning assist the service provider in developing safe and effective traffic solutions and also enable free maneuvering in low-density airspace. TBM used by an increasing number of en route facilities. Operations on structured routes only exist in high-density areas to avoid terrain and active SUA, and to facilitate the transition between areas with differing separation standards. Data link services include air traffic control clearances, current and forecast weather, notices to airmen and hazardous weather warnings, updated charts, current weather, SUA status, and other required data. Sector boundaries are modified to accommodate dynamic traffic flows. Multiple navigation paths are available to all suitably equipped users. These auto-negotiated and automatically loaded routes allow aircraft to perform at or near their most efficient profile even when the user preferred trajectory is not available.
International Oceanic	Most aircraft meet required navigation and communication performance to allow for further reductions in lateral and longitudinal separations. Service Providers have a common set of rules and operational procedures for a harmonized enroute/international oceanic system. Positions of all controlled aircraft are determined through automated means and are displayed to the service provider. Separation assurance is accomplished with the aid of DSS's and a visual display system similar to that used in en route. Data link enables seamless communications. Intelligent agents, operating on behalf of the user and service provider, monitor the flight environment, analyze conditions and auto-negotiate proposed adjustments to the flight profile in response to changes in system constraints.

NAS MANAGEMENT (2)	
NAS management includes Traffic Flow Management (TFM) and Information Management (IM). TFM focuses on the daily planning of operations and the real-time coordination across the NAS to manage large-scale demand-capacity imbalances due to weather, special events, and outages.	
TFM Environment (2.1)	
Problem resolution at lowest appropriate levels to avoid "blanket TFM solutions."	Near-Term
Users are key participants in the planning of TFM initiatives… A TFM information network supports this collaboration and information exchange	Near-Term
With comprehensive information from System Wide Information Management (SWIM) system, users are better able to plan flight operations. SWIM provides access to all known constraint information	Mid-Term
Systems exist that disseminate, execute, and monitor flight-specific TFM agreements	Mid-Term
There are capabilities and strategies to manage airspace congestion that are comparable to those that are used to manage airport capacity imbalances	Mid-Term
Improved Decision Support Systems (DSS) help users and service providers to visualize demand and to manage more complex traffic flows	Mid-Term
The system automatically develops and offers options as close as possible to user requests.	Far-Term
Flow constrained areas are managed by allocating access, collaborative rerouting, and realigning sectors and associated resources	Far-Term
The National Weather Service tracks and projects weather systems using constantly updated data. Using this data fused with the automatically received data from airborne platforms, flow managers have accurate information to use in developing TFM initiatives	Far-Term
TFM - User Perspective (2.2)	
Users have access to an increasing amount of NAS information, including airport status and acceptance rate and composite weather information	Near-Term
Users sharing strategies with the FAA Command Center allows service providers to evaluate conditions based on current user intentions rather historic data	Near-Term
Working with service providers, users better manage flight operations by collaboratively evaluating the situation, developing reroutes around the flow constrained areas, and providing a more refined allocation of flights to the reroutes	Near-Term
Users plan flight profiles that consider known constraints and provide the best advantage to their operations	Mid-Term
Users have capability to exchange slots in congested airspace with other users as well as improved collaborative rerouting around flow constrained areas down to the individual flight	Mid-Term
Alternative flight plans are filed simultaneously and are tested on a continuing basis as trial plans are selected if conditions do not develop as foreseen	Mid-Term
Airport and airspace congestion is initially managed by allocating the constrained resources to users based on anticipated scheduled and unscheduled demand. Flights are then interactively replanned against both current constraints and any ancillary problems that arise.	Far-Term

TFM - Service Provider Perspective (2.3)	
FAA Command Center monitors demand-capacity balance of major traffic flows with a broader strategic focus than that of local service providers. This activity makes extensive use of predictive capabilities that are enhanced by more comprehensive and current information from users and international service providers.	Near-Term
FLIGHT PLANNING, EMERGENCY, AND ALERTING SERVICES (3)	
Flight planning improvements focus on meeting user needs through interactive collaboration with the service provider. This interaction creates dynamic, event driven, user-preferred trajectories for individual flights.	
Flight Planning, Emergency, and Alerting Services - Environment (3.1)	
Operators of properly equipped aircraft file their preferred routes from departure airport Standard Instrument Departure (SID) to arrival airport Standard Terminal Arrival Route (STAR), or airport to airport. User-preferred routes are based on waypoints in addition to NAVAIDS.	Near-Term
Real time sharing of system demand and the virtual ATM information enabling service providers and users to mutually develop solutions to problems	Near-Term
Flight plan information is incorporated in flight profiles. Flight profiles can be as simple as the user's preferred path or as detailed as a time-based trajectory that includes the user's preferred path and preferred climb and descent profiles.	Mid-Term
Flight profiles are automatically checked against various conditions and constraints and potential problems are displayed to the user for reconciliation	Mid-Term
Aircraft will transition to improved Emergency Locator Transmitters (ELT) that utilize discrete codes and satellite navigation positioning to aid in SAR	Mid-Term
Interactive flight planning capabilities with immediate access to real-time data are fully implemented and are available throughout the flight to the flight deck, flight operations center, and service provider. User preferred routing is available to all properly equipped aircraft for both domestic and international flights. Controlled Times of Arrival (CTA) are the primary method for regulating flows in the planning, tactical, and strategic timeframes.	Far-Term
Emergency and alerting services provide information available for all active flights. If a flight experiences an unplanned contact with the ground, there is automatic notification to the appropriate parties	Far-Term
Flight Planning, Emergency, and Alerting - User Perspective (3.2)	
Electronic Flight Bag technology begins to evolve, supporting access to SWIM data, as the move from hard copy to electronic references continues	Near-Term
NAS users receive information about projected areas of concern and revise their plans on a real-time basis	Near-Term
Service providers begin to use Controlled Time of Arrival (CTA) as part of TFM and user flight planning systems incorporate flow management constraints for use when planning	Near-Term
Data link equipped users load flight plans directly into the aircraft FMS. Users obtain complete weather briefings for proposed route via Flight Operations Center (FOC) computers.	Near-Term
SWIM (see SWIM Tab) ensures continuously updated NAS information such as service constraints and infrastructure status. Flight planners use this data to prepare and continually update flight profiles by probing user preferred routing against known system constraints.	Mid-Term
Most aircraft are equipped with advanced navigation and some form of data link communications allowing automated modification of flight profiles while airborne.	Mid-Term
CTAs are the standard response to NAS resource constraints for all users. As conditions change the user is notified and is able to interactively determine the impact of the changes on the flight and modify the flight profile as desired.	Mid-Term

SURFACE (4)	
The goal for surface improvements is to enhance the safety and efficiency of operations and reduce constraints on the user when airport resource demand is high and when low visibility adversely impacts airport operations. Elimination of these constraints minimizes the overall ground delay of arrivals and departures.	
Surface Environment (4.1)	
Using data link, many users have access to ATIS and automated clearance delivery. Data linked meteorological information (current observations, pilot reports, hazardous phenomena)(improves situational awareness.	Near-Term
Moving map displays enhance pilot familiarity with the airport; flight deck capabilities for some users include moving map display and initial conflict alerting logic. Position reports and taxi routes are relayed via data link relieving voice communications frequencies.	Mid-Term
The surface management system facilitates coordination between decision makers at all levels of the airport operation	Mid-Term
Departure and arrival runway assignments are based not solely on parking location but on the surface automation's prediction of congestion and the related taxi plan.	Mid-Term
Widespread data link aircraft equipage allows for pilots to receive RVR, braking action, surface condition reports, current precipitation, runway availability, wake turbulence, wind shear, hazardous weather alerts, and other relevant information	Far-Term
Virtual vision displays in aircraft and appropriate vehicles enable movement in nearly all levels of visibility	Far-Term
Automated systems link the digital taxi clearance and aircraft position on the surface so that airport signage and lighting are correlated to each flight and assist in compliance with the taxi instructions.	Far-Term
Runway incursion alerting devices activated from surveillance processors, in-ground sensors, and onboard systems eliminate runway incursions.	Far-Term
Surface Environment - User Perspective (4.2)	
ACARS in use by many users. Data link allows for limited delivery of weather information and PDC information.	Near-Term
Improved initial taxi and departure coordination with ATC. Flight deck moving map displays begin to incorporate real-time airport status information as appropriate.	Near-Term
The proliferation of CDTI and supporting ground infrastructure takes place. The ground system receives aircraft position reports and broadcasts traffic information and a complete suite of graphical and text products, including precipitation/lightning, icing, low ceiling/visibility maps, surface hazards, and wind shear and turbulence information, as well as site specific weather reports and forecasts.	Mid-Term
Most aircraft are equipped with satellite navigation, moving maps capable of displaying airport maps, graphical and text weather, and traffic information. These systems improve safety on the surface by reducing runway incursions and providing increased situational awareness.	Far-Term
Low visibility taxi operations or "blind taxi" are routine	Far-Term
ARRIVAL/DEPARTURE (5)	
The goal for arrival/departure operations is to effectively manage traffic in the terminal area and demand for airport resources, including aircraft preparing to land and depart and those that are traversing terminal airspace. Arrival/departure operations, however, extend beyond traditional terminal airspace boundaries and include the airspace where aircraft flows are initially adjusted to optimize use of airport resources.	

Arrival/Departure Environment (5.1)	
Departure and arrival routes developed with established RNP criteria become more common. Changes in service provider procedures allow the increased ability to accommodate user-preferred arrival/departure routes, climb/descend profiles, and runway assignment.	Near-Term
New automated aircraft capabilities allow flight crews to more readily monitor terrain and obstructions to avoid CFIT incidents.	Near-Term
Aircraft operate on optimum profiles closer to the airport. The implementation of satellite navigation with vertical guidance makes it possible to provide precision instrument approaches at practically any landing facility.	Mid-Term
Pilots conduct approaches using independent navigation systems and begin monitoring the approach on a moving map display.	Mid-Term
Flight deck traffic displays are used to increase the pilot's situational awareness for maintaining separation and spacing tasks while providing direct information on the presence of wake vortex. When operationally advantageous and mutually agree upon, the service provider may authorize flight deck separation.	Mid-Term
Modifications to service provider procedures and the improvements in turbulence and wake vortex avoidance facilitate a reduction in separation standards.	Mid-Term
Seamless data link is available for most pilot and service provider communications. Some emergency communications are automatically sent to both pilot and the service provider to further increase safety by eliminating the time necessary for a human to relay the message (i.e., wind shear alerts).	Far-Term
Virtually all aircraft are equipped to provide position and intent information and to receive position and intent data from other aircraft.	Far-Term
CTA's are routinely used for managing arrivals through specific portions of the airspace. Dynamic airspace management matches traffic volume to multiple enhanced navigation arrival and departure routes.	Far-Term
Enhanced all-weather landing systems allow multiple paths to final approach to facilitate full use of runway capacity. Virtual vision devices on flight decks enable more "visual-like" operations.	Far-Term
Revised separation standards are now adjusted and applied based on real-time detection of wake turbulence and actual aircraft type criteria for both arrivals and departures.	Far-Term
Arrival/Departure - User Perspective (5.2)	
Data link continues to be used for routine contact with flight operations centers to provide position, flight profile information, aircraft status information, and accurate arrival/departure times. Aircraft execute FMS offset approaches/departures and parallel RNP/RNAV routes to increase system throughput.	Near-Term
Visual operations are enhanced with improved traffic situational awareness, enabling pilots to better execute spacing tasks. Terrain databases are expanded to include towers and other obstructions to avoid CFIT incidents.	Near-Term
Aircraft equipped with improved flight deck displays depicting all relevant traffic enable pilots to visually acquire traffic, thereby enabling approaches and departures in reduced visibility.	Mid-Term
Aircraft with increased capabilities receive more user-preferred routings and altitude profiles.	Mid-Term
Approaches and departures are conducted in IMC at or near VMC rates	Mid-Term
Most aircraft are equipped with advanced avionics, enabling free maneuvering operations in low-density airspace	Far-Term
Pilots negotiate the most desirable profile to follow in terminal airspace. In high-density areas, dynamic airspace management makes multiple dynamic RNP/RNAV arrival and departure routes. Routes are sent via data link to pilots in properly equipped aircraft.	Far-Term
EN ROUTE (6)	
As the system evolves, en route airspace structures and boundary restrictions are unconstrained by communications and computer systems, and aircraft are no longer required to fly between NAVAIDS along static routes defined by the FAA.	

En Route - Environment (6.1)	
RVSM provides more efficient use of airspace and allows more users to fly at optimal altitudes. A ground based conflict probe facilitates a reduction in restrictions and allows users to receive more preferred profiles, even in non-radar airspace.	Near-Term
Time based metering is used to meter arrivals into select high density and demand locations which improves the management of flights transitioning from en route to terminal airspace.	Near-Term
Users navigate and monitor own ship position using GPS, RNP/RNAV, or other area navigation capability, along with the introduction of multi-function flight deck displays to depict traffic, terrain, and weather, to reduce in-flight and CFIT incidents.	Near-Term
Technology enhancements, combined with procedures, permit separation minima based on overall system performance.	Mid-Term
Separation procedures differ depending on the flight's equipage and the quality of the surveillance data.	Mid-Term
Properly equipped aircraft receive an increase number of services via data link.	Mid-Term
Free maneuvering supported by airborne and ground conflict management capabilities is available in low-density airspace	Long-Term
Time based metering becomes a routine operation throughout the NAS and aircraft receive CTA's to transition points and are allowed to navigate on a parabolic flight profile to meet that time.	Long-Term
En Route - User Perspective (6.2)	
The flight operations center monitors the status of the NAS and relays status information to pilots. As the service provider has a conflict probe to provide more efficient and effective trial planning, the flight operations center and flight deck are able to request and receive more in-flight trajectory changes	Near-Term
There is increased collaboration between the flight operations center and air traffic management as the flight operations center interactively probes proposed route changes. Collaboration is extended as flight operations centers have an expanded role in developing the arrival flow of company flights.	Mid-Term
Routings are routinely flown from SID to STAR or from departure-to-destination, and airborne holding is adjusted to maximize airport use.	Mid-Term
Users operate aircraft along negotiated routes that account for system constraints such as weather, congestion, and special activities.	Far-Term
INTERNATIONAL OCEANIC (7)	
Improvements in navigation, communications, and surveillance require global harmonization to achieve capacity and efficiency enhancements in international oceanic airspace. Reductions in separation standards are facilitated through an improved infrastructure and aircraft equipage. Automation and procedural changes help service providers to strategically solve potential conflicts and traffic congestion and allow user-preferred trajectories.	
International Oceanic Environment (7.1)	
International oceanic airspace capacity is limited by separation standards and established route structures necessitated by limited surveillance and communications structures.	Near-Term
Due to limited real-time surveillance and large latencies for communication exchange separation standards are large and navigation errors are often undetected.	Near-Term
Limited reduction of horizontal and vertical separation minima occurs for properly equipped aircraft	Near-Term
With increased equipage, most aircraft are able to meet the required navigation and communication performance to allow further reduction in lateral and longitudinal separations. More precise monitoring of separation and flight progression is achieved through automatic dependent surveillance (ADS).	Mid-Term
While planning remains strategic, the reduced time to establish common situational awareness and to execute the planning process allows the final decision time to be closer to	Mid-Term

implementation.	
Direct access from the flight deck to SWIM provides improved timely access to flight conditions, including graphical weather, volcanic ash, solar flare radiation, and reported turbulence.	Mid-Term
User preferred routes replace the track system.	Far-Term
Increased airspace capacity is achieved through further reductions in separation minima.	Far-Term
The positions of all controlled aircraft are determined through automated means and are displayed to the service provider.	Far-Term
International Oceanic - User Preference (7.2)	
Evaluations of air-to-air surveillance for procedural enhancements are ongoing. Enhanced in-trail climbs and descents, as well as lead climbs and descents, are available on a pair-wise basis for properly equipped aircraft.	Near-Term
The increased capacity of the flight deck and ground systems allow users to plan for and negotiate flexible entry points into the route structure and maximize the flight's efficiency. The entry point is provided as a point in space with a required time of arrival.	Mid-Term
Satellite-based communications and electronic message routing support cooperative activities among flight crews, flight operations centers, and service providers.	Mid-Term
Users operate aircraft along negotiated routes that account for system constraints such as weather, congestion, and special activities.	Far-Term
Flight operations centers and the flight deck can continuously monitor the flight environment via SWIM< and propose adjustments to profiles whenever conditions change.	Far-Term
System Wide Information Management	
In today's Air Traffic Management (ATM) system, information is generally managed within and between discrete systems and processes. When an information item is needed, a point-to-point methodology is implemented to service the specific initiative. As different uses for the data item emerge, additional discrete transfer mechanisms are instituted. The result is a variety of technical, organizational, and institutional barriers that prevent easy and timely access to relevant information.	
The System Wide Information Management (SWIM) concept aims to define information at the overall system level, rather than at each major subsystem (e.g., program, process, and function) and interface level as occurs today. The intent is to integrate the ATM network in an information sense, not just in a system sense. In addition to a pool of common information, SWIM provides context-sensitive information to National Airspace System (NAS) elements that may require it.	
As the NAS evolves from a human-based/human-centric operating model to a human-based/information-centric, SWIM will be the cornerstone upon which automated authentication, decision support suites, and intelligent agents are built. SWIM recognizes that decisions made by controllers, pilots, and dispatchers represent information that is used by the others as inputs to their own planning and decision making processes. The goal is to provide an integrated picture of the past, present, and planned state of the NAS to serve as a common basis for improved decision making.	

ICAO ANConf/11-WP/4		
Major Concept Area	**Sub-Area**	**Characteristics**
2.2 Airspace organization and management		All airspace will be the concern of ATM and will be a useable resource. The organization, the flexible allocation and the use of airspace will be based on the principles of access and equity.
		Airspace will be organized to accommodate the needs of the different types of users on a timely basis. Transition between areas will be transparent to the users at all times.
	2.2.5 Airspace organization	Airspace management will be dynamic, flexible and based on services demanded.
		Airspace will be organized to facilitate seamless handling of flights and the ability for flights to be conducted along optimum flight trajectories from gate to gate without undue restriction or delay.
		Airspace planning will be based on accommodating dynamic flight trajectories whenever practicable. Structured route systems will only be established in areas where the demand for dynamic trajectories cannot be accommodated.
	2.2.6 Airspace Management	Airspace management is the process by which the airspace organization options and other options in the provision of services will be selected and applied to best meet the needs of the airspace users. Competing interests for the use of airspace will make management a highly complex exercise, necessitating a process that equitably balances those interests.
		Airspace use will be coordinated and monitored in order to accommodate the conflicting legitimate requirements of all users and to minimize any constraints on operations.
		Structured route systems will be applied only where required to enhance capacity or to avoid areas where access has been limited or where hazardous conditions exist.
2.3 Aerodrome operations		Aerodrome operations describe the aerodrome functionality within the ATM system in terms of such factors as information acquisition and delivery, facility access, demand on airspace and limits on usability.
		Aerodrome operation principles include runway occupancy time will be reduced and the ability to safely maneuver in all weather conditions while maintaining capacity.
		Precise surface guidance to and from a runway will be required in all conditions. The position (to an appropriate level of accuracy) and intent of all vehicles and aircraft operating on the maneuvering and movement areas will be known and available to the appropriate A TM community members.
2.4 Demand and capacity balancing		Demand and capacity balancing will allow airspace users to optimize their participation in the ATM system while mitigating conflicting needs for airspace and aerodrome capacity. Collaborative usage of decision support tools will ensure the most efficient use of airspace resources; provide the greatest possible access to airspace resources; provide equitable access for all airspace users; accommodate user preferences; and, ensure that demand on an airspace resource will not exceed its capacity.
		Advance demand and capacity balancing information will be made available to all airspace users and service providers, including aerodrome operators, to establish a common understanding of needs and capabilities.

ICAO ANConf/11-WP/4		
Major Concept Area	**Sub-Area**	**Characteristics**
2.5 N/A		
2.6 Airspace user operations		The ATM system will accommodate diverse types of airspace user missions. These are expected to encompass, but are not limited to, air transport, military missions, business, aerial work and recreation. These missions will have differences in planning horizons; from scheduled well in advance to just prior to flight.
		The evolution of ATM services will provide operational benefits and incentives commensurate with aircraft capabilities. It will have to be recognized, however, that the degree to which benefits and incentives can be realized may continue to differ with respect to the types of users. The development of ATM system and aircraft capabilities based on global standards, will ensure global interoperability of ATM systems and airspace user operations.
		Individual aircraft performance, flight conditions, and available ATM resources will allow dynamically optimized 4-D trajectory management.
		Mission planning is performed by airspace users as a collaborative exercise with airspace organization and management, aerodrome operations and demand and capacity balancing as appropriate to ensure that the A TM system will be able to accommodate their mission.
		Aircraft capabilities consistent with the applicable airspace management requirements will allow airspace users to fly user-preferred trajectories.
2.8 ATM service delivery management		
	2.8.2 Trajectory, profile, and aircraft or flight intent	The future ATM system based on this concept, will rely on explicit and unambiguous information and on wide information exchange within the system. Key information relates to the future position of aircraft, and to the meaning and status of that information.
		System-delivered trajectories will take into account aircraft performance characteristics.
		The notification of intent will be a means for airspace users to specify their request for services and the nominal capabilities available during the flight.
		The notification of intent will satisfy the gate-to-gate, collaborative decision-making and network management requirements.
2.9 Information services		
	2.9.2.4 Information management	The ATM community will depend on information management, shared on a system-wide basis, to make informed collaborative decisions for best business and operational outcomes. Within the ATM system based on this operational concept, it will be the information itself that will be of significance and not the technology that supports it.

EATM 2000+ Document		
Major Concept Area	**Sub-Area**	**Broad Description**
3.3 ATM Security		To determine effective mechanisms and procedures to enhance the response of ATM to security threats and events affecting flights (aircraft and passengers) or the ATM system.
		Although ATM cannot by itself address all issues, it nevertheless has to provide responsible authorities with the requested help in all phases of the security occurrence in accordance with national, ICAO and other relevant international rules. The international dimension imposes the uniform and effective application of suitable measures.
3.5 Capacity		To provide sufficient capacity to accommodate the demand of all users in an effective and efficient manner at all times, and during typical busy our periods without imposing significant operational, economic or environmental penalties under normal circumstances.
	3.5.3 Airport Capacity	To enable airports to make the best use of potential capacity, as determined by the infrastructure in place (land-side and air-side), political/environmental restrictions, and the economical use of resources.
	3.5.4Access	To enable all users a fair access to airspace, airports and required ATM services.
	3.5.5 Delay	To increase overall ATM network capacity in line with traffic demand, to ensure that ATM-induced delays are not a significant constraint, and that the percentage of traffic delayed by ATM is less than today.
	3.5.6 Predictability	To improve the predictability of flight operations by reducing ATM-related variations in gate-to-gate transit times.
	3.5.7	To increase the responsiveness of ATM services to real-time changes in airspace users´ needs.
	Flight Efficiency	To enable all airspace users to operate as efficiently as possible while accommodating both civil and military operators' needs.
6.3 Airspace Organization and Management		The principles underlying the Flexible Use of Airspace concept together with advances in avionics and altimetry, the further development of area navigation techniques, and satellite-based navigation systems capable of providing more accurate and timely position information, will provide the cornerstones for progressive improvements in the way that airspace is managed and used.
	6.3.1 Simplification of Airspace Organization	The main objective will be to optimize the organization of the entire European airspace to permit the maximum freedom of movement for all Airspace Users.
	6.3.3 Utilization of User-Preferred Trajectories	Advances in aircraft navigational capabilities complemented by advanced ATC support tools will facilitate the phased implementation of free route airspace concept in ECAC airspace and thus enable Airspace Users to freely plan and fly their preferred trajectories. A possible related ultimate evolution in this direction for change, and in relation to aircraft separation could be the delegation of separation assurance tasks to the flight deck in designated portions of the airspace. This would be achieved after a period of initial application of separation assurance criteria as specified in ATC clearance, such as station keeping.
	6.3.4 Route Network Optimization	Overall, more direct and fuel-efficient routes will be available, together with by-pass routes to avoid busy traffic areas.

EATM 2000+ Document		
Major Concept Area	**Sub-Area**	**Broad Description**
	6.3.5 Terminal Airspace Optimization	Implementation of the objective will be realized through improving aircraft performance capabilities leading to, in the long term, the ultimate goal of 4D RNAV capabilities in Terminal Airspace.
	6.3.6 ATC Sector Design Optimization	The objective is to increase capacity by moving to an entirely flexible airspace structure, whereby airspace sector boundaries are adjusted to particular traffic flows and peaks in demand in real-time, and are not constrained by National boundaries.
	6.3.7 ATM procedures	As a consequence of the effects that evolving concepts and new technologies may have on current safety arrangements for air traffic operations, and in support of the Gate-to-Gate concept, there is an ongoing requirement to develop and validate new and/or revised ATS procedures which enhance safety whilst leading to improved operational efficiency.
6.4 Flow and Capacity Management		Changes will centre 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 recognized that this will still entail flow regulation under certain conditions.
	6.4.1 Strategic Flow and Capacity Planning	Strategic Flow and Capacity Planning is aimed at analyzing the evolution of the forecast demand and the identification of potential problems and in evaluating possible solutions. Developments in information technology, in data sharing and CDM will permit greater access to information, and in combination with improved capabilities of ground organizations, enable the production of Seasonal Forecasts for all stakeholders.
	6.4.2 Optimized Capacity Management	ATFCM will progressively change from the reactive management of demand to the proactive management of capacity and empower stakeholders to align their own plans against the ADP. This will be achieved, in the longer term, through collaborative analysis and decision making to enable stakeholders to identify problem areas and to negotiate and agree potential solutions with ATFCM.
	6.4.3 Tactical Flow and Capacity Management	Tactical Flow and Capacity Management aims to maintain the plan (ADP) consistent with the real time picture, safely and efficiently, to react to any non forecasted event and to make information on the capacity and traffic situation available to all partners, enabling them to take the best benefit of any opportunity.
	6.4.4 Flight Planning	The objectives of Flight Planning are to facilitate flight planning and achieve universal access to common flight data including the profile of the flight. It concerns interaction and CDM between Airspace Users and ATFCM on an individual flight plan.
6.5 En-Route and Terminal Air Traffic Control		Future operational improvements will involve the use of enhanced computer processing powers, and more sophisticated computer assistance tools and human-machine interfaces, to provide automated assistance for some routine ATC tasks, and to improve shorter-term planning. radiotelephony (RT) will be augmented by air-ground data communications, initially as a means of transferring non-critical messages (in terms of both time and safety), but this could eventually be extended to include some critical messages in certain circumstances. The net effect will be to reduce ATC workload per flight and thereby increase the potential capacity of the ATM network.

EATM 2000+ Document		
Major Concept Area	**Sub-Area**	**Broad Description**
	6.5.2 ATC Decision Support	Decision Support Tools will be further enhanced by using aircraft derived data: as a first step using interoperability between AOC and ATM systems to enhance the accuracy of ATC trajectory prediction; then by direct transfer of discrete parameters from aircraft to ground systems; and finally, when ATM systems will receive aircraft generated trajectory data from current aircraft position to destination. The comparison between the flight plans used in airborne FMS and ground ATM systems is expected to greatly enhance safety and efficiency.
	6.5.4 Interoperability, Communications and Surveillance Efficiency	Currently ATC Units are interconnected through on line data interchange (OLDI). In view of consistency with future enhancements, in particular the use of aircraft derived data, it will be necessary to introduce new forms of interoperability and wider availability of data. All users of flight data, will need a source of up-to-date, consistent, complete flight information for all planned and active flights that cross Europe. This will facilitate efficient information exchange between ground systems and aircraft Flight Management Systems (FMS) and provide a common view on the ATS environment to ground and airborne systems, including trajectory information and the operation of ATC tools and planning of flights without consideration of the boundaries of areas of responsibilities.
	6.5.5 Co-operative ATS	The introduction of air-ground and air-air data link, improvements to communications and greater automation will facilitate the sharing of data between air and ground systems in real time. This, in turn, will pave the way for co-operative ATS (COOPATS) that will: • Provide for full information sharing between the air and ground; • Optimize the provision of flight data to the ATM ground system and other authorized users (such as meteorology); • Evolve towards an ATM environment where air-ground communication becomes an automated and secondary task; • Support autonomous flight operations in designated airspace.
		The Common Trajectory Co-ordination (COTRAC) service supports optimal use of user-preferred trajectories. The purpose of which is to establish and agree 4D trajectory contracts between aircrew and controllers in real time using graphical interfaces, air and ground data communications and automation systems (in particular the FMS), by means of a structured negotiation method in order to significantly enhance ATM capacity and flexibility. The co-ordination of trajectories will be performed more effectively by involving Airline Operations Centers in the loop. COTRAC will enable trajectory based ATM.
6.6 Airport ATC		The cumulative effect of planned improvements, together with related changes in other core ATM processes, will provide the basis for the enhancement of traffic throughput in low visibility conditions, so that declared airport capacity can be consistently applied in all weather conditions. However, full realization of full airside capacity gains is also dependent on complementary landside improvements.

EATM 2000+ Document		
Major Concept Area	**Sub-Area**	**Broad Description**
	6.6.1 Traffic Management on the Movement Area	Safety will be enhanced through the implementation of improved tools and procedures for conflict detection and alert, as well as improved ground guidance systems that increase situational awareness both in the cockpit and on the ground.
	6.6.2 Airport Capacity Management	The aim is to develop management information techniques using CDM and Systems Wide Information Management (SWIM) processes that will generate efficient flows of aircraft from/to the runway system in order to optimize arrival and departure streams.
	6.6.3 Airport Throughput	The aim is to optimize the airport maneuvering area traffic flows and the minimization of ground and airborne delays. Implementation will be technologically orientated, supported by new cockpit and ground procedures, and will be realized through enhanced arrival and departure management tools which sequence and meter traffic to maximize runway utilization.
6.7 System-Wide Information Management		
	6.7.1 Information Sharing	Today's information barriers arise because most ATM legacy systems have been developed and built independently and bottom-up, thereby preventing the easy exchange of information even though it may be readily available in isolated systems. In some instances, the same information is created several times in several places by different systems. In addition, some actors are extremely reluctant to share information, which they consider to be "commercially sensitive".
		By introducing common information management concepts for all ATM information, SWIM will ensure that the information needs of stakeholders within and outside the ATM system can be satisfied in a much more cost-effective, flexible and efficient way than today. This should also allow working in a closed loop that includes the AOC and flight deck.
	6.7.2.2 AIS in Collaborative Decision-Making and System-Wide Information Management	The development of CDM tools necessary to support the future global ATM network will require access to global aeronautical information of the required quality. The aim, within the framework of system wide information management, will be to move to a system that provides on-line quality aeronautical information to users in real-time. To achieve this, aeronautical information must be provided in electronic form based on a commonly agreed and standardized data model. Strict quality principles will be put in place to ensure that aeronautical data is available, verified and validated.
	6.7.4 Meteorological Services	All phases of flight can be significantly affected by meteorological conditions. Safety, regularity and efficiency of air traffic will increasingly depend upon the timely, accurate, complete and up-to-date availability of Meteorology (MET) information to pilots, controllers, and planners.

Effecting ATM Change

The numerous ATM enhancement opportunities presented by technological developments in recent years have a downside in that those opportunities need to be balanced against operational effectiveness and economic practicality.

1 General

1.1 The implementation of enhancements in the ATM system requires not only addressing the technical aspects of the change(s) under consideration, but also a number of related factors that condition both the operational effectiveness and the economic practicality. This section presents the main factors at stake.

Aligning Implementation

1.2 There have been numerous developments in recent years that can impact the way that flight operations, and in particular approach and landing operations, could be conducted. The aviation community has to focus on those concepts and services that have a high probability of being implemented in an airplane and being used operationally.

1.3 A significant number of heritage approach and landing services are being supplemented by evolving service provisions that can support various levels of approach and landing operations. Some of these services can also support other terminal area operations.

1.4 As operating fleets transition from older aircraft fleets to modern technology aircraft, new functionality is introduced. This includes an evolving mix of capabilities and an expansion of the aircraft operating ability. This is a reality that has been in place since the start of aviation. What has changed is the rate of introduction of evolving potential alternatives in recent years.

1.5 In addition to financial reasons to coordinate the implementation of new equipment on the flight deck, proliferation of additional equipment on the flight deck also impedes human factors friendly operation of the aircraft. It is important, from a safety perspective, that introduction of required equipment on the flight deck remains coordinated to reduce potential for crew mistakes. This is true for general aviation aircraft as well as large commercial aircraft. The flight crew task will become unmanageable if all opportunities are embraced, the aviation community has initiatives in place to simplify flight crew tasks to reduce the potential for error that could affect safety.

1.6 A similar situation applies with respect to ground ATM System and ATM service providers. In some areas, ground based ATM capability is ahead of flight deck capability – however in many more areas, it is years behind flight deck capability. At the same time, many of the developments in ATM service delivery are based around the extension of current and past operating practices. The ATM Operational Concept has identified the need to redefine, at fundamental levels, the roles and operating methods of all members of the ATM community while ensuring that during this process we retain a safe and economically viable system that provides benefits and allows for sustained growth. That shift needs to be reflected in the transition strategies.

1.7 The variety in aircraft capabilities is also reflected in the varying capabilities of emerging ATM systems. It is important to recognize that while some States have implemented systems capable of exploiting emerging technologies and applications such as data link and advanced flight data processing capabilities, many States have not.

1.8 Without a careful transition to the fundamental redefinition referred to above it may not be possible to consistently deliver all of the operational improvements that are being considered, which may lead to instability in the global ATM network. It is therefore necessary to select those improvements that can most easily integrate into a continuously evolving transitional process involving systems with a wide range of capabilities, while still providing significant benefits across all timeframes.

1.9 The aviation community cannot afford to implement all of the concepts being espoused assuming all other considerations are put aside. Significant resources are necessary to assess and refine all 'opportunities' to an implementable state – these resources are often not available. Decisions to change the air traffic management system that require changes to aircraft equipment or airworthiness configuration can have substantial adverse impacts on aircraft operations if not planned and integrated into normal maintenance cycles. Therefore it is imperative that adequate lead time be available to plan, budget and schedule aircraft upgrades.

1.10 For the business aircraft operator the key driver is aircraft availability. Due to the small size of most business aviation flight departments there is a reliance on the OEM to be able to develop a maintenance program or appropriate supplemental type certificate for the new equipment. For legacy fleets this becomes an especially important issue, since most operators do not have their own engineering staff. There is also the issue of airplanes whose manufacturers are no longer in business and the ability of 3rd party STC's to accomplish the upgrade. In situations like this an operator of an orphaned aircraft needs to be able to continue operating the aircraft or have an ability to upgrade the aircraft through a viable solution.

1.11 The maintenance actions not only include traditional continued airworthiness action, but also frequently include actions framed by the more tactical non-ATM commercial operating environment - specifically passenger amenity or cargo facilitation. Changes to enhance ATM effectiveness make up a relatively small component of the normal maintenance program, and while critical for more effective ATM, are generally viewed as more strategic actions in the current economic environment.

1.12 Increasingly, as individual operations span multi-States and regions, uncoordinated ATM-related changes in various service provider regions can result in competition for valuable maintenance downtime. It is critically essential that as well as providing sufficient notice of change, there is global coordination to ensure that the requirements for operations across various regions can be accommodated in a timely and efficient manner.

1.13 Air Traffic Management must be viewed as a highly coordinated evolutionary process, requiring planned periodic changes rather than reactive changes in configuration – both of aircraft systems, and ground infrastructure. For most aircraft operators, provided the change is coordinated sufficiently far in advance, that change can be effectively accommodated.

1.14 The reality that air and ground components of the total ATM system can have quite different lead times is also an issue that needs to be addressed in aligning ATM system improvements. While it may indeed be feasible for the development of a specific ground component to commence, in some cases, several years after the corresponding airborne development, nonetheless service providers will need to commit to those developments according to globally agreed timeframes and standards.

1.15 All stakeholders must avoid the temptation to chase the next new development or modification to standards that are theoretically possible but which may in the end negate years of development and in the end result in few delivered benefits. This is also a consideration for those service providers who commit early to implementing new capabilities in their environments.

1.16 The ground components of the ATM system are often in a better position to ameliorate the situation by finding additional solutions to their specific problems that have, whenever possible, a neutral impact on the airborne components. It may be possible, for example, to identify the minimum required combined air-ground initiatives that will deliver major benefits and then “fill the gaps” to the extent possible, with solutions that are largely independent. These independent elements may then interact with the other elements through a range of simple, clearly defined collaborative processes.

1.17 Conversely, mitigations for air traffic service shortcomings may be accommodated by airborne operational procedures or aircraft system design to produce the most cost effective operation.

2 AIRCRAFT AND ASSOCIATED SYSTEMS

Forward Fit versus Retro-Fit:

2.1 The production lifecycle of an airplane model can span many years and the useful life of any airplane in the product line can be 30+ years. Manufacturers introduce new products as demand requires and as value added products can be provided to the airspace users. The following figure could represent a life cycle of one airplane type. Note that multiple airplane types are in various phases of being designed, certificated, produced, operated, exit production and retired simultaneously at any point in time.

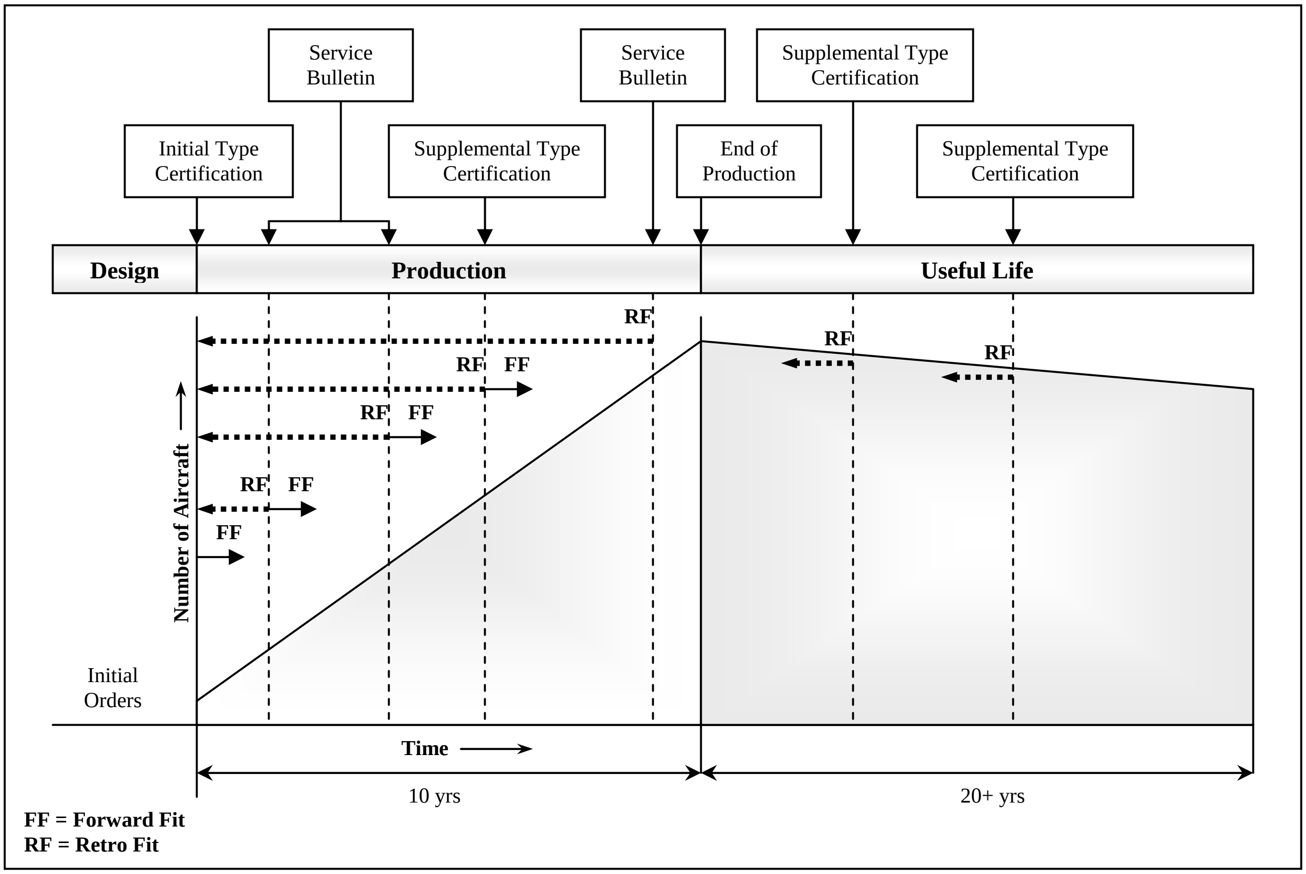


Figure 1: Aircraft Manufacture Life Cycle

2.2 This diagram illustrates the dilemma facing manufacturers and aircraft purchasers in coping with disjointed and uncoordinated ATM development. The normal design time for a new aircraft is around 5 years, with new aircraft designs being produced about every 5 years on average for any one manufacturer. From initial certification, aircraft may be produced for up to 20 years before production ceases. From the time the last aircraft is delivered, it will have a useful operating life in excess of 20 years. Indeed some aircraft are operating safely today at 40 years or more. The certification of an aircraft, particularly a new aircraft, is a difficult and complex task, particularly given the enormous interactions between system components within an aircraft, whether it is a civil airline aircraft, a military aircraft, or a general aviation aircraft. During the initial design and production of the aircraft, the manufacturer has to make certain assumptions and predictions about future ATM interactions and requirements, to build certain "future provisions" into an aircraft, given its predicted useful lifespan. In the business aviation community, the design time for an aircraft is similarly long, while new products are introduced every few years. Business aviation airplanes have a low rate of retirement with 92 percent of the total inventory of produced business jets currently still being in operation around the world. Therefore a natural transition of aircraft going out of service should not be planned when considering ATM changes. Airplanes inherently have long economic life and upgrade paths for all ATM changes should exist.

2.3 Forward fit is the process of building capability into an aircraft from the production line. Retrofit is the process of building that capability into an aircraft after it has left the production line and is in service.

2.4 During the production life of an aircraft, changes to the design of the aircraft are made to introduce improvements and functionality. This may be accomplished by an amendment to the airplane type certification. This is cut into the production line as forward fit. Concurrently, the airplane manufacturer typically produce a Service Bulletin (SB) that will allow previously delivered airplanes to be brought up to the latest functionality (Retrofit). Fleet commonality is important from a training viewpoint.

2.5 Increasing complexity of the airplane flight deck both in proliferation of equipment and non-commonality of the fleet add to the aircrew training time. Increased crew training time not only is a cost by itself, but results in the crew being unavailable for flight operations requiring a replacement crew or a break in operation.

2.6 Aircraft upgrades that take place after the aircraft has left the factory, in particular after out of production are frequently the result of a Supplemental Type Certificate (STC). Over the years, this has resulted in the legacy aircraft fleet having a multitude of equipment solutions available to them. While this facilitates new equipment being introduced into the fleet, it also adds to the complexity of planning for a fleet upgrade to a new ATM solution.

2.7 As can be seen from the diagram above, where a change is initiated early in a production sequence, it can be forward fitted into the majority of produced aircraft and generally economically. The number of retrofit aircraft is also small.

2.8 However, where a change is required to be incorporated late in a production cycle, the number of retro-fit aircraft is very high. Retrofit process also continues after the airplane goes out of production.

2.9 Couple this with the fact that the diagram above represents only one of many production lines, staggered over the last 30 years, and it can be easily seen that technical changes to aircraft fleets to accommodate planned ATM enhancements could affect a significant number of airframes in current operation.

2.10 In looking at ATM evolution, it is therefore critical to look first at solutions that do NOT require changes to aircraft or their avionics, or that leverage to the maximum extent possible capabilities that have already been incorporated into the majority aircraft design. It is also necessary to pre-plan a stable change regime over long time spans, to provide predictability and stability of operations.

2.11 Where aircraft system changes are required, and given the level of system integration in aircraft, it is essential that those changes are coordinated globally, so that when an aircraft operator makes a change to an aircraft, it covers ALL likely scenarios on a global basis.

Useful Life of an Airplane

2.12 Airplanes have a ‘useful’ life that is influenced by a number of factors. As an airplane approaches the end of its useful life, there is a reluctance to invest significant amounts of money in improvements.

Airplane Residual Value

2.13 An airplane is a valuable asset to an operator and its marketability value is important. A common configuration for an airplane allows an airplane to ‘move’ more easily between international operators and increases its residual value. Commonality is a significant benefit for airplane leasing companies.

Cost of Unscheduled Downtime

2.14 When proposing changes to aircraft in support of ATM enhancements, it is useful to understand the scale of possible effects of unscheduled rather than scheduled downtime.

2.15 At the high end of the scale, an operator/owner will have to replace the aircraft taken out of service with a wet-leased aircraft, without the ability to use its own crews.

2.16 At the low end of the scale, an operator/owner may be able to schedule the requirement within the window of existing scheduled maintenance checks. While there may only be incremental costs, it should be recognized that operators schedule downtime very tightly, and depending on the size of the retrofit or change, other items may need to be deferred.

2.17 In the middle ground, an operator/owner may have to provide for additional aircraft hours by increasing fleet size. Changes may be easier to manage in a large fleet of like aircraft, however it is often more difficult to manage in a small fleet, with a high likelihood of having to lease additional aircraft. If regulatory requirements are expected to recur for different reasons, then existing fleets generally have a margin for regulatory requirements, retrofit costs are real but not directly observed. If a change is viewed as a one-time requirement then an operator may handle the change in context of fleet plan by adjusting aircraft acquisition/retirement dates, or by adjusting leases, if possible.

2.18 There have been recent instances of airplane modification programs being developed based on published ATM service providers published plans for deployment. Subsequently, these plans have been withdrawn after operator and airplane manufacturers' costs have been invoked. Such decisions will destroy any confidence in provider plans and make the airspace users reticent to make any substantial investment in the future.

Additional considerations

2.19 Additional considerations to be addressed from an airspace user perspective include:

Cascading Benefit

2.20 Cascading benefits come about when functionality is added to the airplane that in turn opens up additional operational capabilities when combined with systems and capabilities. This type of functionality is valued by the aviation community as it helps make the business case for implementation.

2.21 Both service providers and ATM system suppliers need to be aware of the significance of this issue and look for simple ways to achieve such benefits. This implies that throughout the evolution process there needs to be a constant feedback across industry with regard to new or refined concepts, using established functionalities that can have a significant global or regional impact.

Seamless versus Interoperable

2.22 Initially, these terms may appear to be interchangeable – experience has shown that interoperability often comes with caveats. These caveats frequently translate into airplane system modifications and/or crew procedures. The global ATM system should strive for seamless operations.

Window of Economic Opportunity and Latency

2.23 The paradigm of 'it will get done when it gets done' cannot be applied to the ATM system. Windows of opportunity open and close as time marches on. One example could be a new airplane program. Decisions are made on what functionality to provide in a new airplane based, in part, on the perceived 'maturity' of service provisions and standards and the level of confidence that the provision will occur.

2.24 If the capability is not designed and ordered into a new aircraft at time of manufacture then a retrofit scenario will be necessary with its associated costs, schedule and complexities. The ATM system obviously can not be directly linked to airplane programs but missing service provision schedules, or even creating the impression of an impending slide in provision (i.e., latency) can have a significant impact on provisioning decisions.

2.25 Many more examples could be provided but the key message is as uncertainty and unpredictability increases the likelihood of accomplishing the transition plan diminishes rapidly (i.e. the confidence factor).

Operational Readiness – "the Trigger for Change"

2.26 The airspace users cannot afford to carry non-value added capability around in the airplane. Equipage decisions are based on near term return on the equipage investment. With complex, highly integrated airplane systems, adding functionality may involve multiple items of equipment and coordination of changes to that equipment. Operators, the airplane manufacturers and the airplane equipment manufactures cannot afford to have a continuous rotation of equipment for modification. Structured update programs are necessary (i.e., Windows of Economic Opportunity).

2.27 The trigger for change occurs when functionality can be provided at a reasonable cost and operational benefits can be realized in a timely manner. Aircraft demonstrators should be used to confirm the benefits (safety, operation and cost) of each new configuration.

2.28 Aircraft manufacturers, ATM system suppliers, service providers (indeed all ATM community members) must coordinate the planning of developments to ensure that the air and ground capabilities are able to be implemented at the same time. The discussion above about carrying non-value added capabilities in the aircraft can also be applied to ATM systems. Service providers and ATM system suppliers need to see equipage programs that ensure that when a capability is provided there will be a return on investment. There will necessarily be situations where a capability has to be provided as a building block for future capabilities rather than as an immediate generator of benefit; in those cases, incentives may need to be considered.

2.29 A key to making progress is to 'reward' those who contribute positively to the efficiencies of the global airspace system.

Commitment – "Staying the Course"

2.30 This is the process of producing a plan that user can rely on, make decisions against and have confidence that the advertised benefits will be realized. Once a transition plan is agreed to with the Stakeholders, there needs to be confidence that the plan will be followed to completion.

3 ATM SYSTEMS

The ATM System Upgrade Dilemma

3.1 ATM service providers who invested in new systems typically expected a lifetime in the order of 15 years before system replacement. In the days when systems were essentially radar display systems with limited Flight Data Processing (FDP) capabilities that strategy was indeed practical and effective. Today the replacement of a complete ATM system is a lengthy and expensive process that usually entails considerable investment in new infrastructure elements and extensive retraining and redefinition of procedures. The pace of change also means that a “15 year” cycle is no longer viable.

3.2 Services providers therefore need to acquire systems that are readily upgradeable over a long period and capable of the integration of new and advanced capabilities that may have been at (or even beyond) the limits of imagined evolution at the time of the new systems conception.

3.3 As a strategy to assist in resolving these issues there is a move by service providers to try to achieve the required upgrade capabilities by specifying very open systems in which it is possible to integrate components from a variety of sources. While this process is to some extent achievable, like the airborne issue discussed above, the required interoperability or connectivity will also come with caveats that may limit the overall effectiveness of the new concepts. In addition ATM system suppliers, like aircraft manufacturers, are very concerned to preserve what they may consider a commercial advantage conferred by product capabilities. If this conflicts with “openness” then they may be reluctant to act and industry as a whole must find ways to address the problem. Several recent regional initiatives have started to address this issue and are leading to strong levels of cooperation between a range of system suppliers and end users.

3.4 Of course individual service providers will be driven by their own business models and/or State requirements. This may mean that if a given provider sees no economic benefit in implementing certain concepts then the industry as a whole must find ways to achieve the desired results without leaving “black holes”. This may mean that it is necessary to have some form of “regional business model” that is subscribed to by a number of providers.

3.5 From the ATM system supplier’s viewpoint the development of a complete “new generation” system is also a lengthy and costly exercise. Very few can afford to “go it alone” without the assurance of a major customer. The customer however needs the assurance that the system that will be delivered several years later will be on time and meet the needs expressed at the time of concept as well as having the desired long term upgrade capabilities.

3.6 The situation can in fact be eased if there is a long term view of the fundamental nature of the new concepts that will be introduced and if the number of such new concepts is limited to a relative few for which it is easy to quantify the cost benefits and for which there is a high degree of assurance of success. The new concepts must also be able to have a high degree of independence from specific technological solutions. For example a new concept may require data link: it should not matter to the concept what technical solution(s) are implemented on the airborne side.

ATM Ground System Products Are Not Like Aircraft Products

3.7 It is fundamental to the understanding of the evolution of the total ATM System to recognize that the two key components, the aircraft and the ground based ATM System, are very different from a ‘product’ perspective.

3.8 A commercial aircraft model tends to be produced in the hundreds, and sometimes thousands, of units. The manufacturer will develop the concept of the new aircraft (or major new development of an existing model) but will not proceed unless a significant number of units are ordered from a number of launch customers.

3.9 ATM ground systems are different. While suppliers may espouse a product policy and to some extent achieve something that approaches a product, the fact remains that such systems are produced at very best in tens, more often in units and frequently as unique installations. Major new developments are generally launched with a single customer. Even where a strong product policy is applied each delivery generally requires quite a number of significant evolutions to meet the specific customer needs and operating environment.

3.10 It is possible to produce something approaching a generic product to serve certain sections of the ATM system market but at the level of major systems this is rarely the case. This means that the evolution of new components must take account of ‘retro-fit’ or re-use requirements. This often imposes additional cost pressures on the development of any given system. The development of harmonized concepts and operational procedures across service providers will therefore be essential to the successful and cost effective implementation of the new ‘global’ ATM network.

The Track Record for New ATM System Implementation Is Not Perfect

3.11 The number of failures in the delivery of major ATM systems over recent years is high when measured from the perspective of achieved cost, delivery on time, and delivered versus requested functionality. The reasons for such failures are many but among those that directly impact the implementation of the future ATM system are:

- Specification creep;
- Lack of understanding of end-user requirements by the supplier;
- Lack of integrated operational/functional concepts from the end-users:
  - Sometimes reflected in an un-integrated “shopping spree” attitude on the part of the customer;
  - Sometimes manifesting itself as a major mid-term change of direction or redefinition;
- Underestimation of software development required; and
- Lack of clear transition planning.