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Global Air Navigation Plan for CNS/ATM Systems

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International Civil Aviation Organization

AMENDMENTS

The issue of amendments is announced regularly in the *ICAO Journal* and in the monthly *Supplement to the Catalogue of ICAO Publications and Audio-visual Training Aids*, which holders of this publication should consult. The space below is provided to keep a record of such amendments.

RECORD OF AMENDMENTS AND CORRIGENDA

AMENDMENTS			
No.	Date of issue	Date entered	Entered by

CORRIGENDA			
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CNS/ATM SYSTEMS

Definition

Communications, navigation, and surveillance systems, employing digital technologies, including satellite systems together with various levels of automation, applied in support of a seamless global air traffic management system.

Strategic vision

To foster implementation of a seamless, global air traffic management system that will enable aircraft operators to meet their planned times of departure and arrival and adhere to their preferred flight profiles with minimum constraints and without compromising agreed levels of safety.

Mission of implementation

To develop a seamless, globally coordinated system of air navigation services that will cope with worldwide growth in air traffic demand while:

- improving upon the present levels of safety;
- improving upon the present levels of regularity;
- improving upon the overall efficiency and capacity of airspace and airports
- improving operations allowing for capacity increase while minimizing fuel consumption and aircraft engine emissions;
- increasing the availability of user-preferred flight schedules and profiles; and
- minimizing differing equipment carriage requirements between regions.

FOREWORD

Since the conclusion of the work of the Special Committee on Future Air Navigation Systems (FANS) in October 1993, the International Civil Aviation Organization (ICAO) has significantly progressed the development of material necessary for the planning, implementation and operation of communications, navigation, and surveillance/air traffic management (CNS/ATM) systems. Today, Standards and Recommended Practices (SARPs), Procedures for Air Navigation Services (PANS) and guidance material on all defined elements and aspects of CNS/ATM systems are largely in place. Development of ICAO provisions will continue in line with identified requirements.

As technology advances, new systems and concepts will continue to emerge, offering potential improvements in terms of safety, efficiency and/or economy of international flights. This document, which is an updated and enhanced version of the "Global Co-ordinated Plan for Transition to the ICAO CNS/ATM Systems" contained in the *Report of the Fourth Meeting of the Special Committee for the Monitoring and Co-ordination of Development and Transition Planning for the Future Air Navigation System (FANS Phase II)* (Doc 9623), has been produced to include recently developed concepts and systems. The plan has also been expanded beyond its technical scope to include relevant economic, organizational, environmental, legal and technical cooperation issues and also a global planning methodology expected to guide regional planning groups in their implementation planning work.

One of the objectives of this revised Global Plan is to define and illustrate ICAO's process for CNS/ATM systems planning and implementation as a logical progression of the work already accomplished. This includes an analysis of the structured relationship between the global, regional and national planning processes as well as the relationship between the Global Plan and other ICAO planning activities. An inventory of materials, tools and documentation now in existence, indicating where and how these can be used, will provide a readily-available source of reference material for planning purposes.

Recognizing that effective ATM is essential to ensuring safety, regularity and efficiency of international civil aviation and that implementation of available and emerging technologies should fulfil the requirements for a global ATM system, this plan broadly describes an ATM operational concept being developed by ICAO, and reflects the latest available information on ATM conceptual work. This description and emerging concept offers a high-level vision in order to assist in the determination of ATM requirements that will guide the development of future CNS/ATM system elements and their functionalities, thereby allowing optimum benefits to be attained. This new approach is designed to lead initially to improved harmonization of air traffic services (ATS) and ultimately to a globally integrated ATM system.

As work on the ATM operational concept is ongoing, consensus on several emerging concepts have to be reached (e.g. autonomy of flight*, separation assurance*, situational awareness*, required total system performance (RTSP)*, required communication performance (RCP)*, required surveillance performance (RSP)*). The operational requirements and functional specifications of some technologies (automatic dependent surveillance-broadcast (ADS-B)*) also have to be developed. Where these issues and/or technologies are addressed in the Global Plan, they are accompanied by a footnote indicating that work and consensus is still to be achieved through the ICAO process.

The Global Plan offers background information on the different elements and entities involved in CNS/ATM systems planning and implementation with the goal of creating, within one document, a nucleus of information necessary to facilitate the move towards the next phase of CNS/ATM planning and implementation. At the same time, the Global Plan attempts to bring up to date, in a consolidated format, the progress generally achieved by the regions and illustrates, with appropriate time lines, the work remaining, forming the implementation schedule for the future. It also offers, under one cover, a global snapshot of progress achieved and work remaining toward the implementation of CNS/ATM systems, thereby serving as a consolidated planning tool.

The Global Plan has a clear and functional relationship to the regional air navigation plans (ANPs). This has been

* Emerging concept or technology — consensus still to be reached.

accomplished by dividing the Global Plan into two parts: the *Operational Concept and General Planning Principles* (Part I), which provides guidance for the further development of the Basic Operational Requirements and Planning Criteria (BORPC) of the regional ANPs; and Part II, *Facilities and Services for the Implementation of the Global Plan*, which reflects more detailed material and relates to the Facilities and Services Implementation Documents (FASIDs) used in the regional planning process.

Parts I and II together provide the means for a step-by-step approach, including an operational analysis, to planning for implementation of global CNS/ATM systems. To begin the process, several homogeneous ATM areas and major international traffic flows have been identified in Part I, Chapter 3. The tables in Part II were generated with the purpose of assisting the planning and implementation regional groups (PIRGs) in further identifying the inter-regional CNS/ATM systems infrastructure necessary to support the implementation of homogeneous ATM areas and major international traffic flows.

Because of the relationship being established between the updated Global Plan and the regional ANPs, it is necessary for the Global Plan to have a clear association with all aspects of traditional regional air navigation planning. This will not only facilitate the work of the PIRGs, but is considered a necessary aspect of successful implementation of CNS/ATM systems. For this reason, the Global Plan provides introductory material in the fields of meteorology and aeronautical information services related to the implementation of CNS/ATM systems. Aerodrome operations, normally a part of regional air navigation planning, is not addressed separately in this version of the Global Plan because of the regional nature of this type of planning. Relevant ATS aspects associated with aerodrome operations in future environments are addressed within the context of overall ATM planning, while specific ATM objectives related to aerodrome operations are identified in the tables in Part I, Chapter 4, and in Part II, Chapter 5 of the Global Plan.

The emerging technologies will support a variety of system designs and implementation options. The challenge for the planner and designer is to develop an adequate understanding of the costs, benefits and operational suitability of these alternatives while considering the legal, organizational, environmental and financial aspects; to orchestrate a coordinated programme of ATM improvements that takes into account the user's needs, their willingness to upgrade their capabilities to achieve operational benefits, and also to pay for the changes required by ATM services providers. The Global Plan is intended to guide the international aviation community toward meeting this challenge and implementing CNS/ATM systems.

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LIST OF ACRONYMS

A-SMGCS	Advanced SMGCS
AAC	Aeronautical administrative communications
AAIM	Aircraft autonomous integrity monitoring
ABAS	Aircraft-based augmentation
ACARS	Aircraft communication addressing and reporting system
ACAS	Airborne collision avoidance system
ACC	Area control centre
ADS	Automatic dependent surveillance
ADS-B*	ADS-broadcast
AFS	Aeronautical fixed service
AFTN	Aeronautical fixed telecommunication network
AIDC	ATS inter-facility data communications
AIP	Aeronautical information publication
AIS	Aeronautical information service
ALLPIRG	All Chairmen of the Planning and Implementation Regional Groups
AMHS	ATS message handling system
AMSS	Aeronautical mobile-satellite service
ANC	Air Navigation Commission
ANP	Regional air navigation plan
ANS	Air navigation service
ANSEP	Air Navigation Services Economics Panel
AOC	Aeronautical operational control
APANPIRG	Asia/Pacific Air Navigation Planning and Implementation Regional Group
APC	Aeronautical passenger communications
APIRG	Africa-Indian Ocean Planning and Implementation Regional Group
ASDE	Airport surface detection equipment
ASECNA	Agency for the Safety of Air Navigation in Africa and Madagascar
ASHTAM	A special series NOTAM notifying by means of a specific format change in activity of a volcano, a volcanic eruption and/or a volcanic ash cloud that is of significance to aircraft operations
ASM	Airspace management
ATC	Air traffic control
ATFM	Air traffic flow management
ATIS	Automatic terminal information service
ATM	Air traffic management
ATMCP	Air Traffic Management Operational Concept Panel
ATN	Aeronautical telecommunication network
ATS	Air traffic services
ATSC	Air traffic services communications
BORPC	Basic operational requirements and planning criteria
CAA	Civil aviation administration
CAEP	Committee on Aviation Environmental Protection
CASITAF	CNS/ATM Systems Implementation Task Force
CATCs	Civil aviation training centres
CDTI	Cockpit display of traffic information
CNS	Communications, navigation and surveillance
CNS/ATM	Communications, navigation, and surveillance/air traffic management
COCESNA	Central American Safety Services Corporation
CPDLC	Controller-pilot data link communications
DARP	Dynamic air route planning
D-ATIS	Digital-automatic terminal information service
DCPC	Direct controller-pilot communications
EANPG	European Air Navigation Planning Group
EATMS	European ATM System
ECAC	European Civil Aviation Conference
EUROCONTROL	European Organisation for the Safety of Air Navigation
FANS Phase II	Special Committee for the Monitoring and Coordination of Development and Transition Planning for the Future Air Navigation System
FANS	Special Committee on Future Air Navigation Systems
FASID	Facilities and services implementation document
FDPS	Flight data processing system
FESG	Forecasting and Economic Analysis Support Group

* Emerging concept or technology — consensus still to be reached.

FIC	Flight information centre
FIR	Flight information region
FIS	Flight information service
FMS	Flight management system
FPL	Flight plan
FUA	Flexible use of airspace
GBAS	Ground-based augmentation systems
GES	Ground earth stations
GLONASS	Global orbiting navigation satellite system
GNE	Gross navigation error
GNSS	Global navigation satellite system
GPS	Global positioning system
GREPECAS	Caribbean/South American Regional Planning and Implementation Group
HF	High frequency
HMI	Human-machine interface
IATA	International Air Transport Association
IAVW	International airways volcano watch
ICAO	International Civil Aviation Organization
IFR	Instrument flight rules
ILS	Instrument landing system
IMC	Instrument meteorological conditions
INS	Inertial navigation system
IPCC	Intergovernmental Panel on Climate Change
IRS	Inertial reference system
ISO-OSI	International Organization for Standardization — Open Systems Interconnection
JAA	Joint Aviation Authorities
LTEP	Panel of Legal and Technical Experts on the Establishment of a Legal Framework with Regard to GNSS
MAP	Aeronautical charts
MASPS	Minimum aircraft system performance specifications
MET	Meteorological services for air navigation
MIDANPIRG	Middle East Air Navigation Planning and Implementation Regional Group
MLS	Microwave landing system
MMR	Multi-mode receiver
MNPS	Minimum navigation performance specifications
MNT	Mach number technique
MWO	Meteorological watch office
NAMPG	North American Planning Group
NAT SPG	North Atlantic Systems Planning Group
NDB	Non-directional radio beacon
NOTAM	Notice to airmen
NPA	Non-precision approach
NPV	Net present value
OPMET	Operational meteorological information
PA	Precision approach
PANS	Procedures for Air Navigation Services
PANS-ATM	*Procedures for Air Navigation Services — Air Traffic Management* (Doc 4444)
PAR	Precision approach radar
PIRG	Planning and implementation regional group
PSR	Primary surveillance radar
RAFC	Regional area forecast centre
RAIM	Receiver autonomous integrity monitoring
RAs	Resolution advisories
RCP*	Required communication performance
RDT&D	Research, development, trials and demonstrations
RF	Radio frequency
RFI	RF interference
RGCSP	Review of the General Concept of Separation Panel
RNAV	Area navigation
RNP	Required navigation performance
RSP*	Required surveillance performance
RTSP*	Required total systems performance
RVSM	Reduced vertical separation minimum
SADIS	Satellite distribution system for information relating to air navigation
SAR	Search and rescue
SARPs	Standards and Recommended Practices
SBAS	Satellite-based augmentation
SCAR	SADIS cost allocation and recovery scheme
SIDs	Standard instrument departures
SIGMET	Information concerning en-route weather phenomena which may affect the safety of aircraft operations
SIGWX	Significant weather
SMGCS	Surface movement guidance and control systems
SSR	Secondary surveillance radar
STARs	Standard instrument arrivals
STDMA	Self-organizing time division multiple access
STP	Standardized training package
SUA	Special use airspace
TCAC	Tropical cyclone advisory centres
TCB	Technical Co-operation Bureau
TCDC	Technical cooperation amongst developing countries
TDMA	Time division multiple access

* Emerging concept or technology — consensus still to be reached.

TDWR	Terminal Doppler weather radar
TIS-B	Traffic information service broadcast
TLS	Target level of safety
TMA	Terminal control area
UNFCCC	United Nations Framework Convention on Climate Change
UTC	Coordinated universal time
VAAC	Volcanic ash advisory centre
VDL	VHF digital link
VFR	Visual flight rules
VHF	Very high frequency
VMC	Visual meteorological conditions
VOLMET	Meteorological information for aircraft in flight
VOR	VHF omnidirectional radio range
VSAT	Very small aperture terminal
VSM	Vertical separation minimum
WAFC	World area forecast centre
WAFS	World area forecast system
WGS-84	World Geodetic System — 1984

PART I

Operational Concept and General Planning Principles

Chapter 1

INTRODUCTION TO CNS/ATM

BACKGROUND

Air traffic environment

1.1 The air transport industry has grown more rapidly than most other industries through the 1980s and 1990s. Between 1985 and 1995, air passenger travel and air freight on scheduled services grew at average annual rates of 5.0 and 7.6 per cent, respectively. Over this same period, aircraft departures and aircraft-kilometres grew at average rates of 3.7 per cent and 5.8 per cent, respectively. The annual changes in scheduled aircraft movements are illustrated in Figure I-1-1.

The FANS Committee

1.2 Having considered the steady growth of international civil aviation preceding 1983, taking into account forecasts of traffic growth and perceiving that new technologies were on the horizon, the Council of ICAO at the time, considered the future requirements of the civil aviation community. It determined that a thorough analysis and reassessment of the procedures and technologies that had so successfully served international civil aviation over the many years was needed. In further recognizing that the systems and procedures supporting civil aviation had reached their limits, the Council took an important decision at a pivotal juncture and established the Special Committee on Future Air Navigation Systems (FANS). The FANS Committee was tasked with studying, identifying and assessing new technologies, including the use of satellites, and making recommendations for the future development of air navigation for civil aviation over a period of the order of 25 years.

1.3 The FANS Committee determined that it would be necessary to develop new systems that would overcome limitations of conventional systems and allow ATM to develop on a global scale. The future systems would be expected to evolve and become more responsive to the needs of users whose economic health would be directly related to the efficiency of these systems. The FANS Committee concluded that satellite technology offered a viable solution to overcome the shortcomings of conventional ground-based systems and to meet the future needs of the international civil aviation community.*

1.4 The FANS Committee further recognized that the evolution of ATM on a global scale using new systems would require a multidisciplinary approach because of the close interrelationship and interdependence of its many elements. Understanding that coordination and institutional issues could eventually arise with new concepts, and realizing that planning would have to be carried out at the worldwide level, the FANS Committee recommended to the ICAO Council in its final report that a new committee be established to advise on the overall monitoring, coordination of development and transition planning. This would ensure that implementation of future CNS/ATM systems would take place on a global basis in a cost-effective and balanced manner, while still taking into account air navigation systems and geographical areas.

1.5 In July 1989, the ICAO Council, acting on the recommendation of the FANS Committee, established the Special Committee for the Monitoring and Coordination of Development and Transition Planning for the Future Air Navigation System (FANS Phase II).

1.6 In October 1993, the FANS Phase II Committee completed its work. The FANS Phase II Committee recognized that implementation of related technologies and expected benefits would not arrive overnight, but would rather evolve over a period of time, depending upon the present aviation infrastructures in the different States and regions, and the overall requirements of the aviation community.

1.7 The FANS Phase II Committee also agreed that much of the technology they were considering was already becoming available and that work should begin by gathering information and, where possible, accruing early benefits using available technologies.

* Since the FANS Committee concluded its work, several alternative technologies have been identified, including terrestrially-based systems, which are described in this version of the Global Plan.

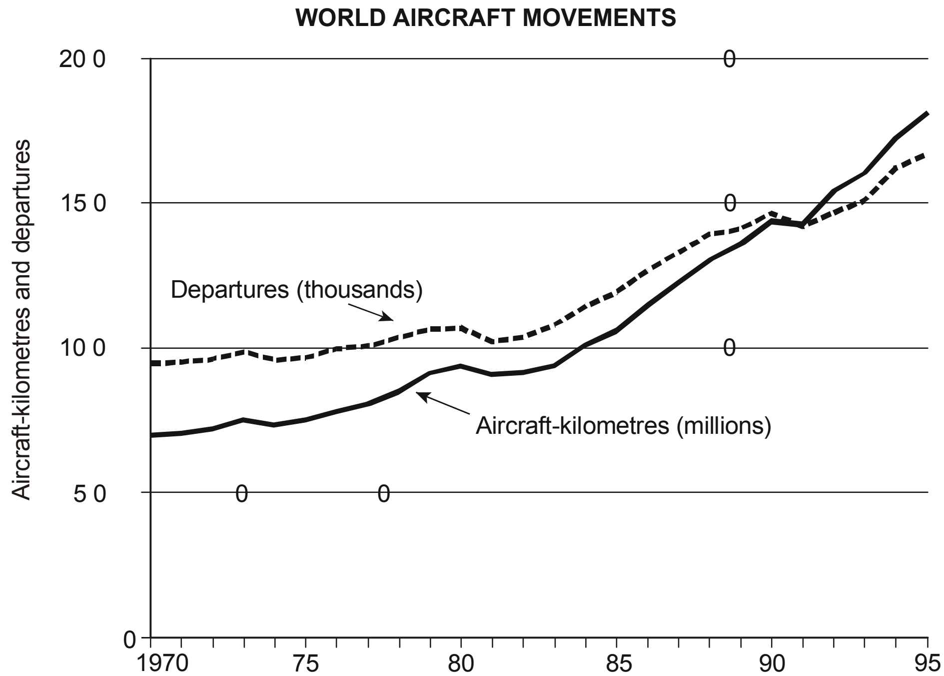

Figure I-1-1. Annual changes in scheduled aircraft movements

The Tenth Air Navigation Conference

1.8 In September 1991, 450 representatives from 85 States and 13 international organizations gathered at ICAO Headquarters in Montreal, Canada, at the Tenth Air Navigation Conference, to consider and endorse the concept for a future air navigation system as developed by the FANS Committees, that would meet the needs of the civil aviation community well into the next century. The FANS concept, which became known as the communications, navigation, surveillance/air traffic management (CNS/ATM) systems, involves a complex and interrelated set of technologies, dependent largely on satellites. CNS/ATM is the vision developed by ICAO with the full cooperation of all sectors of the aviation community to accommodate the future needs of international air transport.

1.9 The result of the Conference encapsulated a set of universally agreed upon recommendations covering the full spectrum of CNS/ATM activities, which continue to offer guidance and direction to the international civil aviation community as they plan and implement the technical and operational aspects of CNS/ATM systems.

1.10 The endorsement of the CNS/ATM systems reached at the Tenth Air Navigation Conference signalled the beginning of a new era for international civil aviation and paved the way for the many activities related to the planning and implementation of new systems around the world.

1.11 During the follow-up of the Tenth Air Navigation Conference, the ICAO Council re-emphasized the important role of regions and States with regard to the planning, implementation and transition to CNS/ATM systems and reiterated the need for a high degree of participation of the ICAO regional offices in their respective planning and implementation roles.

1.12 Further to the work and recommendations of the ICAO Council on CNS/ATM systems, the 29th ICAO Assembly approved two resolutions, which were consolidated at the 31st ICAO Assembly (Appendix B to Chapter 2 refers). These resolutions further endorse and support speedy implementation of CNS/ATM systems.

Global planning

1.13 In order to progress implementation of CNS/ATM systems, a plan of action was needed. The first such effort towards developing a plan was the ICAO Global Coordinated Plan for Transition to ICAO CNS/ATM Systems, which was included as an appendix to the *Report of the Fourth Meeting of the Special Committee for the Monitoring and Co-ordination of Development and Transition Planning for the Future Air Navigation System (FANS Phase II)* (Doc 9623). In 1996, the ICAO Council recognized that this plan had served its purpose well and had made a significant contribution toward realizing the vision established by the FANS Committees, while educating the international community on CNS/ATM systems and associated implementation issues. The Council concluded, however, that the CNS/ATM systems had matured; therefore, a more concrete plan which would include all developments, while putting focus on regional implementation, was required.

1.14 In light of the above, the Council directed the ICAO Secretariat to revise the Global Plan as a "living document" comprising technical, operational, economic, financial, legal and institutional elements, offering practical guidance and advice to regional planning groups and States on implementation and funding strategies, which should include technical cooperation aspects. These aspects of CNS/ATM systems are addressed in this revised edition of the Global Plan.

SHORTCOMINGS OF CONVENTIONAL SYSTEMS

1.15 The FANS Committee, early in its work, recognized that for an ideal worldwide air navigation system, the ultimate objective should be to provide a cost-effective and efficient system adaptable to all types of operations in as near four-dimensional freedom (space and time) as their capability would permit. With this ideal in mind, it was recognized that the existing overall air navigation system and its subsystems suffered from a number of shortcomings in terms of their technical, operational, procedural, economic and implementation nature. After close analyses, the FANS Committee ascertained that the shortcomings of current systems (FANS I conducted its work between 1983 and 1988) around the world amounted to essentially three factors:

a) the propagation limitations of current line-of-sight systems;

b) the difficulty, caused by a variety of reasons, to implement current CNS systems and operate them in a consistent manner in large parts of the world; and

c) the limitations of voice communications and the lack of digital air-ground data interchange systems to support automated systems in the air and on the ground.

1.16 Although the effects of the limitations were not the same for every part of the world, the FANS Committee foresaw that one or more of these factors inhibited the desired development of ATM almost everywhere. As the limitations were inherent to the existing systems themselves, the FANS Committee realized that there was little likelihood that the global ATS system of the time could be substantially improved. New approaches were necessary by which the limitations could be surmounted and which would further permit ATS systems to evolve into an ATM system more responsive to the needs of the users. CNS/ATM systems therefore, would have to allow for a considerable improvement in safety, efficiency and flexibility on a global basis.

A BRIEF LOOK AT CNS/ATM

1.17 The four main elements of CNS/ATM systems are summarized below and are dealt with in detail in later chapters of the Global Plan.

Communications

1.18 In CNS/ATM systems, the transmission of voice will, initially, continue to take place over existing very high frequency (VHF) channels; however, these same VHF channels will increasingly be used to transmit *digital data*. Satellite data and voice communications, capable of global coverage, are also being introduced along with data transmission over high frequency (HF) channels. The secondary surveillance radar (SSR) Mode S, which is increasingly being used for surveillance in high-density airspace, has the capability of transmitting digital data between air and ground. An aeronautical telecommunication network (ATN) will provide for the interchange of digital data between end-users over dissimilar air-ground and ground-ground communications subnetworks. The regular use of data transmission for ATM purposes will introduce many changes in the way that communications between air and ground takes place, and at the same time offer many new possibilities and opportunities.

1.19 The benefits expected from the future communications systems lie in the fact that they will allow more direct and efficient linkages between ground and airborne *automated* systems in conjunction with pilot/controller communications. In fact, digital data link can be seen as the key to the development of new ATM concepts leading to the achievement of real benefits.

Navigation

1.20 Improvements in navigation include the progressive introduction of area navigation (RNAV) capabilities along with the global navigation satellite system (GNSS). These systems provide for worldwide navigational coverage and are being used for worldwide en-route navigation and for non-precision approaches. With appropriate augmentation systems and related procedures, it is expected that these systems will also support most precision approaches.

1.21 GNSS, as specified in Annex 10, will provide a high-integrity, high-accuracy and all-weather worldwide navigation service. The successful implementation of GNSS would enable aircraft to navigate in all types of airspace, in any part of the world, offering the possibility for many States to dismantle some or all of their existing ground-based navigation infrastructure. However, the removal of conventional radio navigation aids should be considered with caution and after a safety assessment has demonstrated that an acceptable level of safety can be met and after consultation with users through the regional air navigation planning process.

Surveillance

1.22 Traditional SSR modes will continue to be used, along with the gradual introduction of Mode S in both terminal areas and high-density continental airspace. The major breakthrough, however, is with the implementation of automatic dependent surveillance (ADS). ADS allows aircraft to automatically transmit their position, and other data, such as heading, speed and other useful information contained in the flight management system (FMS), via satellite or other communications links, to an air traffic control (ATC) unit where the position of the aircraft is displayed somewhat like that on a radar display. ADS can also be seen as an application that represents the true merging of communications and navigation technologies, and, along with ground system automation enhancements, will allow for the introduction of significant improvements for ATM, especially in oceanic airspace. Software is currently being developed that would allow this data to be used directly by ground computers to detect and resolve conflicts. Eventually, this could lead to clearances being negotiated between airborne and ground-based computers with little or no human intervention.

1.23 Benefits would be derived quickly through ADS in oceanic and some continental areas that currently have no radar coverage.

1.24 ADS-broadcast (ADS-B)* is another concept for dissemination of aircraft position information. Using this method, aircraft periodically broadcast their position to other aircraft as well as to ground systems. Any user, whether airborne or on the ground, within range of the broadcast, receives and processes the information. All users of the system have real-time access to precisely the same data, via similar displays, allowing a vast improvement in traffic situational awareness.

Air traffic management

1.25 In considering implementation of new communications, navigation and surveillance systems and all of the expected improvements, it can be seen that the overall main beneficiary is likely to be ATM. More appropriately, the advancements in CNS technologies will serve to support ATM. When referring to ATM in the future concept, much more than just air traffic control is meant. In fact, ATM refers to a system's concept of management on a much broader scale, which includes ATS, air traffic flow management (ATFM), airspace management (ASM) and the ATM-related aspects of flight operations.

1.26 An integrated global ATM system should fully exploit the introduction of new CNS technologies through international harmonization of Standards and procedures. Ultimately, this would enable the aircraft operators to conduct their flights in accordance with their preferred trajectories, dynamically adjusted, in the most optimum and cost-efficient manner. Figure I-1-2 illustrates how the utilization of CNS technologies will result inATM benefits.

BENEFITS OF THE NEW SYSTEMS

1.27 CNS/ATM systems will improve the handling and transfer of information, extend surveillance using ADS and improve navigational accuracy. This will lead, among other things, to reductions in separation between aircraft, allowing for an increase in airspace capacity.

1.28 Advanced CNS/ATM systems will also see the implementation of ground-based computerized systems to support increases in traffic. These ground-based systems will exchange data directly with FMS aboard aircraft through a data link. This will benefit the ATM provider and airspace user by enabling improved conflict detection and resolution through intelligent processing, providing for the automatic generation and transmission of conflict-free clearances, as well as offering the means to adapt quickly to changing traffic requirements. As a result, the ATM system will be better able to accommodate an aircraft's preferred flight profile and help aircraft operators to achieve reduced

* Emerging concept or technology — consensus still to be reached.

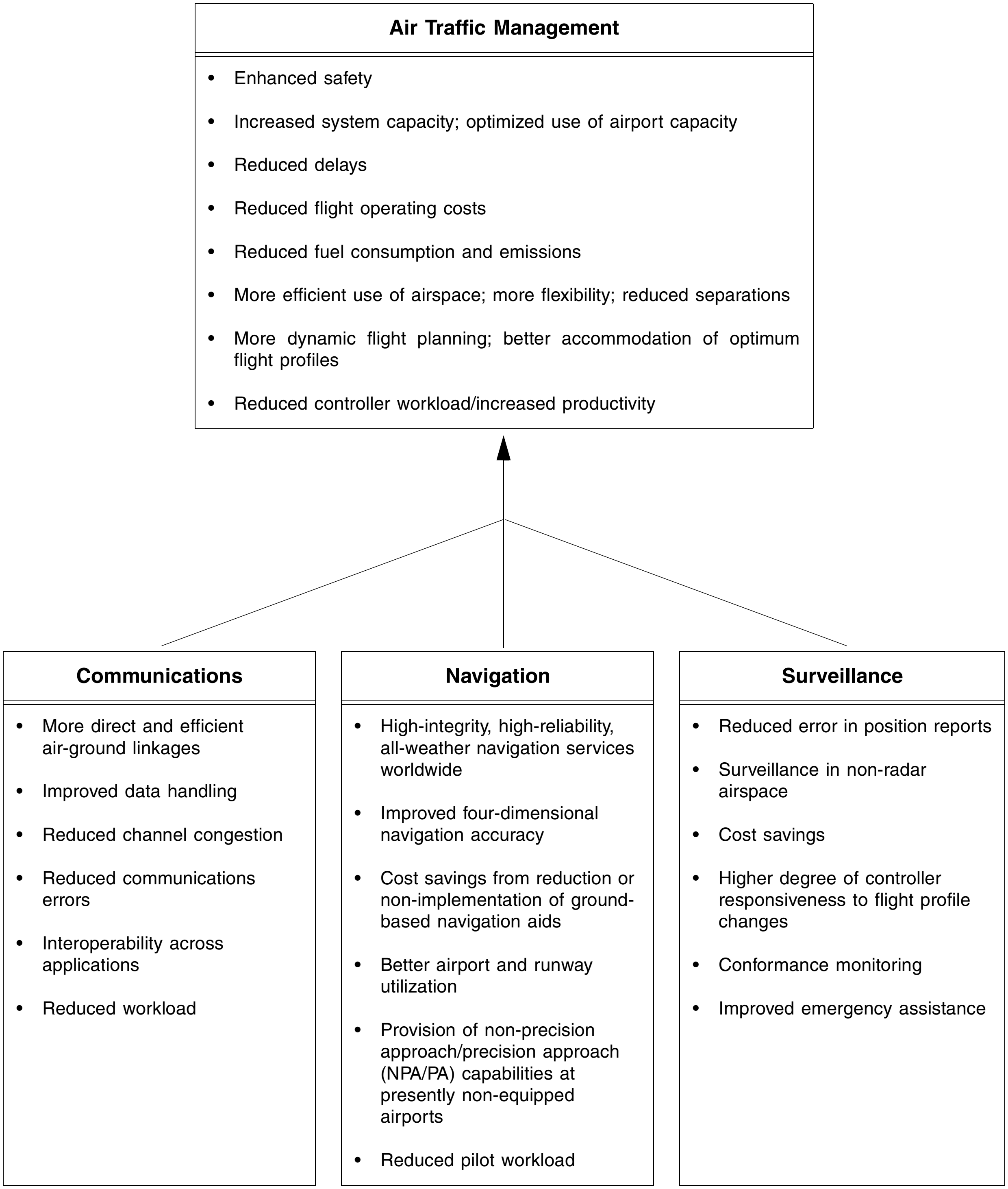

Figure I-1-2. A high-level view of expected benefits of the new systems

flight operating costs and delays. Table I-1-1 describes the objectives and resulting benefits of CNS/ATM systems.

Benefits for the airlines

1.29 The benefits of CNS/ATM systems will ensue through the formation of a more close-knit relationship, allowing rapid and reliable transmission between ground and airborne system elements. More accurate and reliable navigation systems will also allow aircraft to navigate in all types of airspace and operate closer together.

1.30 In anticipation of the advantages of CNS/ATM systems, the airlines expect reduced separation standards over oceanic airspace; increased access to remote areas; the gradual introduction of 1 000 ft vertical separation above 29 000 ft; increased opportunities for more dynamic and direct routings; and an overall enhancement of safety.

Benefits for the States that provide the global air navigation infrastructure

1.31 For those States that provide and maintain extensive ground infrastructures, a reduction in the overall cost of operation and maintenance of facilities is expected as the traditional ground systems become obsolete and satellite technology is increasingly employed. They will also benefit from enhanced safety.

1.32 CNS/ATM provides a timely opportunity for developing States to enhance their infrastructures to handle additional traffic with minimal investment. Many of these States have large areas of available but unusable airspace, mainly because of the expense involved in purchasing, operating and maintaining the necessary ground infrastructures. CNS/ATM systems will afford them opportunities to modernize inexpensively, which includes the provision of precision and non-precision approaches.

Environmental benefits

1.33 As the aviation industry grows more and more rapidly, the impact of air traffic operations on the global atmosphere becomes increasingly important in addition to the local effects of noise and air quality. Efforts to control or reduce the environmental impact of air traffic have identified a range of options that might reduce the impact of aircraft engine emissions. In particular, it is expected that improvements in ATM could help reduce aviation fuel burn, and thereby reduce the levels of aircraft engine emissions.

1.34 ICAO's Committee on Aviation Environmental Protection (CAEP) has developed a methodology and tool for estimating global emissions and fuel usage and evaluating the impact of various CNS/ATM enhancements, which is described in more detail in Chapter 16.

General aviation

1.35 General aviation and utility aircraft will find increasing access to avionics equipment that will allow them to operate in flight conditions, into and out of airports, that they would normally have been prohibited from using because of the operating cost and associated requirements.

1.36 Furthermore, as a result of implementing CNS/ATM systems, many remote areas that are currently inaccessible to most general aviation aircraft because of their inability to communicate or safely navigate over them, would become accessible.

Indirect benefits

1.37 In addition to the direct benefits listed above, there are also many indirect benefits, such as:

— lower fares and rates;

— passenger timesavings;

— transfer of high-technology skills;

— productivity improvements and industry restructuring;

— stimulation of related industries;

— enhanced trade opportunities; and

— increased employment.

COST-BENEFIT STUDIES

1.38 To ensure the successful implementation of CNS/ATM systems, the providers of air traffic services, the users of these services, and financing organizations all need to be advised of the financial implications and convinced of the economic viability of new CNS/ATM systems. This can be achieved through a comprehensive cost-benefit analysis, (complemented by the development of business cases as required), which includes the financial consequences

Table I-1-1. Objectives of CNS/ATM systems

	AIR TRAFFIC MANAGEMENT	FLIGHT OPERATIONS
General	• ensure that all necessary information, including information needed for dynamic flight planning, is available to all ground and airborne systems • enhance functional integration of ground systems with airborne systems and the ATM-related aspects of flight operations • enhance the accuracy of conflict prediction and resolution and the provision of real-time information to controllers and operators	• enhance the accuracy of information related to flight progress • enhance functional integration of airborne systems and flight operations with ground systems • ensure the provision of accurate information between airborne system elements and ground system elements necessary for dynamic flight planning
Safety	• ensure the provision of well-adapted and harmonized safe procedures on a global basis • ensure that separation between aircraft is maintained • ensure that clearance between aircraft and obstacles is maintained • provide for enhanced contingency planning • ensure that rapid alerting service is available • ensure that safety levels are maintained as the use of automation increases	• improve pilot situational awareness* • ensure adequate clearance from terrain • enable aircraft to maintain their own separation under specific circumstances* • ensure that safety levels are maintained as the use of automation increases • ensure integrity of database information
Regularity and efficiency	• provide for the application of global ATM under all operational conditions • improve the application of tactical airspace management through dynamic user involvement, leading to more efficient airspace utilization • improve strategic airspace management while increasing tactical airspace flexibility • ensure the provision of information necessary for tactical and strategic ATFM • enhance overall tactical and strategic ATFM so that demand does not exceed capacity • increase available capacity without increasing controller workload	• ensure that aircraft can operate under all types of weather conditions • provide for the application of user-preferred flight profiles • ensure that the necessary infrastructure is available to support gate-to-gate operations • improve user capability to optimize flight planning dynamically, in order to improve airspace capacity through more flexible operations • minimize aircraft operating cost penalties • minimize differing equipment carriage requirements between regions
	COMMUNICATIONS, NAVIGATION AND SURVEILLANCE	
Communications	• to enhance coverage, accessibility, capability, integrity, security and performance of aeronautical communication systems in accordance with ATM requirements	
Navigation	• to enhance coverage and allow for all weather navigation capability in all airspace, including approach and landing, while maintaining or improving integrity, accuracy and performance in accordance with ATM requirements	
Surveillance	• to enhance and extend effective surveillance to oceanic and remote areas while improving air traffic situational awareness* in the cockpit in accordance with ATM requirements	

* Emerging concept or technology — consensus still to be reached.

affecting all the partners involved in the implementation process. In addition to the assessment of overall viability, it is important to determine the separate impacts on State administrations/organizations responsible for providing the services, and on airlines and other aircraft operators who use the services. For example, some State administrations/ organizations may find that the capital and operational costs of a new system are greater than those at present. On the other hand, any extra equipment and operational costs borne by the airlines are likely to be more than offset by the benefits they receive from more efficient flight paths made possible by the new system. In these circumstances, en-route charges may need to be adjusted to ensure that the costs to the service providers are fully recovered. Business case studies can give guidance on the scope and scale of these adjustments.

1.39 There is a range of technical, operational and institutional options for implementing CNS/ATM systems. For example, air-ground communications in an airspace can be established by aeronautical mobile-satellite service (AMSS) (voice and data), VHF (voice and data), SSR Mode S (data link), HF (voice/data) or any combination of these. With regard to organizational options, a State might independently supply services within its airspace or join forces with other States under various possible arrangements, such as the use of delegated intermediaries. Since the costs and benefits associated with CNS/ATM systems relate to the implementation plan, cost-benefit analysis can help a State or a region to choose the implementation option most appropriate to its needs and conditions.

1.40 A cost-benefit analysis can also provide guidance on the appropriate timing for implementation of various elements of a new system. The relative values of costs and benefits associated with implementation are likely to vary with the volume of traffic. For example, it is possible that benefits from CNS/ATM systems will be more responsive than costs to traffic growth, so that a new system will become more economically attractive as traffic increases over time. It is equally important to recognize that delays in implementation may mean loss of benefits in the near term. A cost-benefit analysis can take into account these facts, and help identify the scheduling of investments that will yield the greatest reward overall.

ORGANIZATIONAL AND FINANCIAL ISSUES

1.41 A major challenge in the implementation process of CNS/ATM systems relates to organizational and financial aspects. A characteristic of many CNS/ATM systems elements is the multinational dimension; consequently, international cooperation will be required to a great extent throughout the implementation process and eventually in the future operational environment. In many cases, financing of basic system elements may need to be a joint venture amongst the States involved at the regional or global level. Financing at the national level would normally be approached in a manner similar to that applied to conventional air navigation systems. The establishment of financially-autonomous authorities to operate air navigation services (ANS) at the national level, and also at the international level, may facilitate solving the financing of CNS/ATM systems.

ASSISTANCE REQUIREMENTS AND TECHNICAL COOPERATION

1.42 While some States will be in a position to develop their national CNS/ATM plans and implement systems using their own resources, the majority of States will require some type of assistance in CNS/ATM planning and implementation. Surveys carried out by ICAO through questionnaires have identified States' requirements for assistance as follows:

a) needs assessments and project development;

b) familiarization and specialized seminars and workshops;

c) transition planning, including cost-benefit and cost-recovery analyses;

d) donor mobilization and financing arrangements;

e) systems planning, specification, procurement, installation and commissioning; and

f) human resource planning and development.

1.43 The Statement of ICAO Policy on CNS/ATM System Implementation and Operation includes, *inter alia*, a stipulation that ICAO shall play its central role in coordinating technical cooperation arrangements for CNS/ATM systems implementation. The ICAO Objectives Implementation Mechanism was established by the 31st ICAO Assembly (Assembly Resolution A31-14 refers) to, *inter alia*, provide the technical assistance required by States in national CNS/ATM systems planning and implementation on a not-for-profit basis. Assistance in the establishment of cooperative arrangements among States, under the auspices of ICAO, e.g. to address common equipment or training requirements, could also be provided.

LEGAL ISSUES

1.44 The legal framework for provision of air traffic management services currently in place, the Chicago Convention and its Annexes, governs the conduct of service providers (including providers of elements of the services, such as navigation aid positioning signals), and users (including air operators). CNS/ATM systems will bring significant benefits to States. It has been generally agreed that there is no legal obstacle to the implementation of CNS/ATM systems and that there is nothing inherent in CNS/ATM systems which is inconsistent with the Chicago Convention. The Panel of Legal and Technical Experts has reached a number of conclusions:

1) GNSS shall be compatible with international law, including the Chicago Convention, its Annexes and the relevant rules applicable to outer space activities;

2) the integrity of any legal framework for the implementation and operation of GNSS requires observance of fundamental principles, which should be established in a Charter; and

3) other legal issues should be further studied as long-term GNSS is developed.

Accordingly, the Panel agreed on the text of a draft Charter on the Rights and Obligations of States Relating to GNSS Services and studied other legal issues related to GNSS. The 32nd Session of the Assembly adopted the Charter (see Appendix A to Chapter 11), which embodies the principles applicable to the implementation and operation of GNSS, including the safety of international civil aviation; universal access to GNSS services without discrimination; preservation of States' sovereignty, authority and responsibility; continuity, availability, integrity, accuracy and reliability of GNSS services; compatibility of regional arrangements with the global planning and implementation process, and the principle of cooperation and mutual assistance. The question on which neither the Council nor the Legal Committee has achieved consensus is whether CNS/ATM presents sufficiently problematic new features that a new legal instrument or combination of instruments is required. A more detailed discussion of the legal issues is set out in Part I, Chapter 11.

SUMMARY

1.45 There are still a number of issues, in addition to those described above, that will have to be dealt with and overcome if all of the possible benefits of CNS/ATM systems are to be fully exploited. This will involve the combined effort and goodwill of both ATM providers and those that operate within the system and who will take advantage of technologies.

1.46 Overall, the CNS/ATM systems are being viewed upon favourably by those who have authority over, and those who operate within, the air navigation system, who realize that air traffic demand has already reached saturation levels in many parts of the world. Early implementation of CNS/ATM systems is already taking place in order to achieve early benefits.

Chapter 2

ICAO'S PLANNING STRUCTURE FOR CNS/ATM

INTRODUCTION

2.1 ICAO's current forecast of the future growth in air transport is depicted in Figure I-2-1. The increasing demands on the global air navigation system can be expressed in terms of aircraft movements at airports and in the airspace. Aircraft departures and arrivals at airports are expected to increase by nearly 30 per cent between 1995 and 2005. Aircraft-kilometres flown are expected to increase by 55 per cent over the same period. Further growth in these parameters is likely in the decade beyond. As traffic volumes grow, the demands on the ATS provider in an airspace increase. For given separation standards, the number of flights unable to follow optimum flight paths increases. This creates pressure to upgrade the level of ATS. In the past, this may have required expenditures on additional facilities such as VHF omnidirectional radio range (VOR) and radar and communications equipment. CNS/ATM systems, however, will provide for increased capacity to meet such demands and will also produce benefits in the way of more efficient flight profiles.

2.2 Although implementation of the new CNS/ATM systems is well under way, the major challenge for ICAO now is to guide the evolutionary development and implementation of a seamless, global ATM system that will enable aircraft operators to meet their planned times of departure and arrival and adhere to their preferred flight profiles with minimum constraints. The first version of the Global Coordinated Plan for Transition to ICAO CNS/ATM systems was an important milestone towards achieving this goal. Transition and implementation remains as the continuing challenge, which poses many difficult and complex issues for those involved in the overall planning and implementation process. Figure I-2-2 illustrates the progression of the work of ICAO toward global ATM.

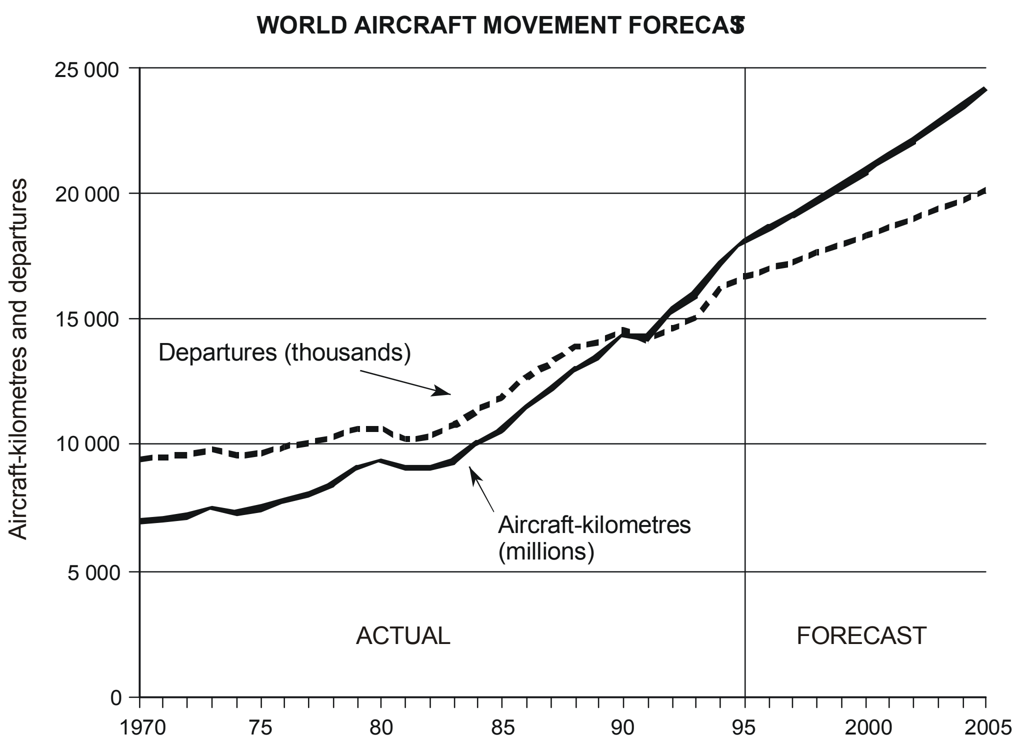

Figure I-2-1. Outlook for world aircraft movements

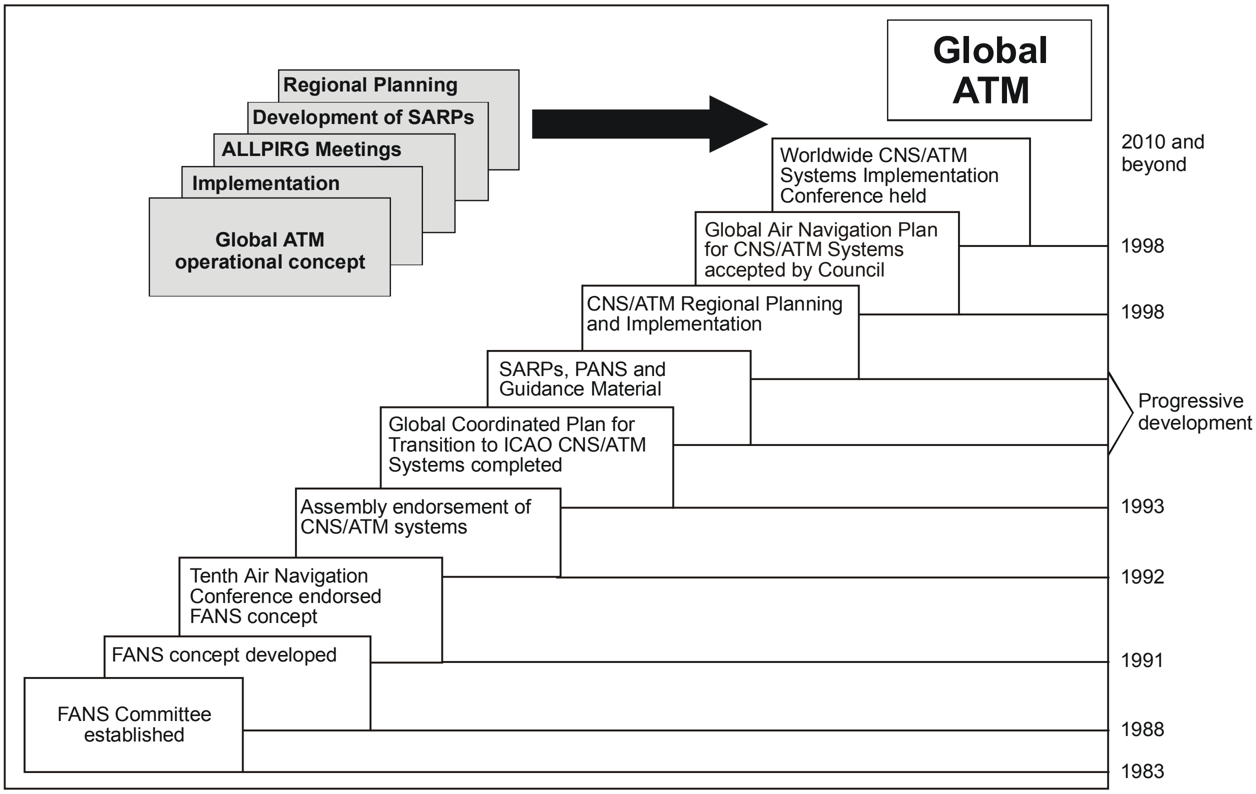

Figure I-2-2. CNSM systems evolution

THE REGIONAL PLANNING PROCESS

2.3 The regional planning process is the principal engine of ICAO's planning and implementation work. It is here that the top-down approach, comprising global guidance and regional harmonization measures, converges with the bottom-up approach constituted by States and aircraft operators and their proposals for implementation options.

2.4 In its most basic form, the output from the regional planning process should be a listing of air navigation facilities and services, together with their achievable time frames, necessary for CNS/ATM systems implementation. These listings are already, or will be, included in the ANPs, which are produced by ICAO regional air navigation meetings and maintained by the ICAO PIRGs with the assistance of ICAO's regional offices (Figure I-2-3 illustrates a hierarchical approach to the planning process in support of global harmonization).

2.5 Traffic forecasts have a special role in planning the implementation of CNS/ATM systems. The forecasts represent the demand for future ATM. The PIRGs must therefore base their work on well-developed traffic density forecasts. The plans developed from this work then specify the infrastructure and arrangements which will supply the required level of ATS. A uniform strategy has been adopted by ICAO for the purpose of preparing traffic forecasts in support of the regional planning process. This involves the establishment of a small group of forecasting experts in each of the ICAO regions. Each traffic forecasting group will provide the corresponding PIRG with forecasts of aircraft movements within homogeneous ATM areas and along major international traffic flows.

THE NATIONAL PLANNING PROCESS

2.6 ICAO has been addressing the planning strategy for CNS/ATM systems at the global and regional levels, leaving the responsibility for undertaking the task of structuring national plans to Contracting States. There is a need for integration and rationalization to ensure harmonization of national planning with planning at other levels. A national plan is required to improve the overall efficiency and capacity of the State airspace infrastructure and to address the requirements arising out of the growth in both international and domestic air traffic. National planning, which is formulated by each State, should be in accordance

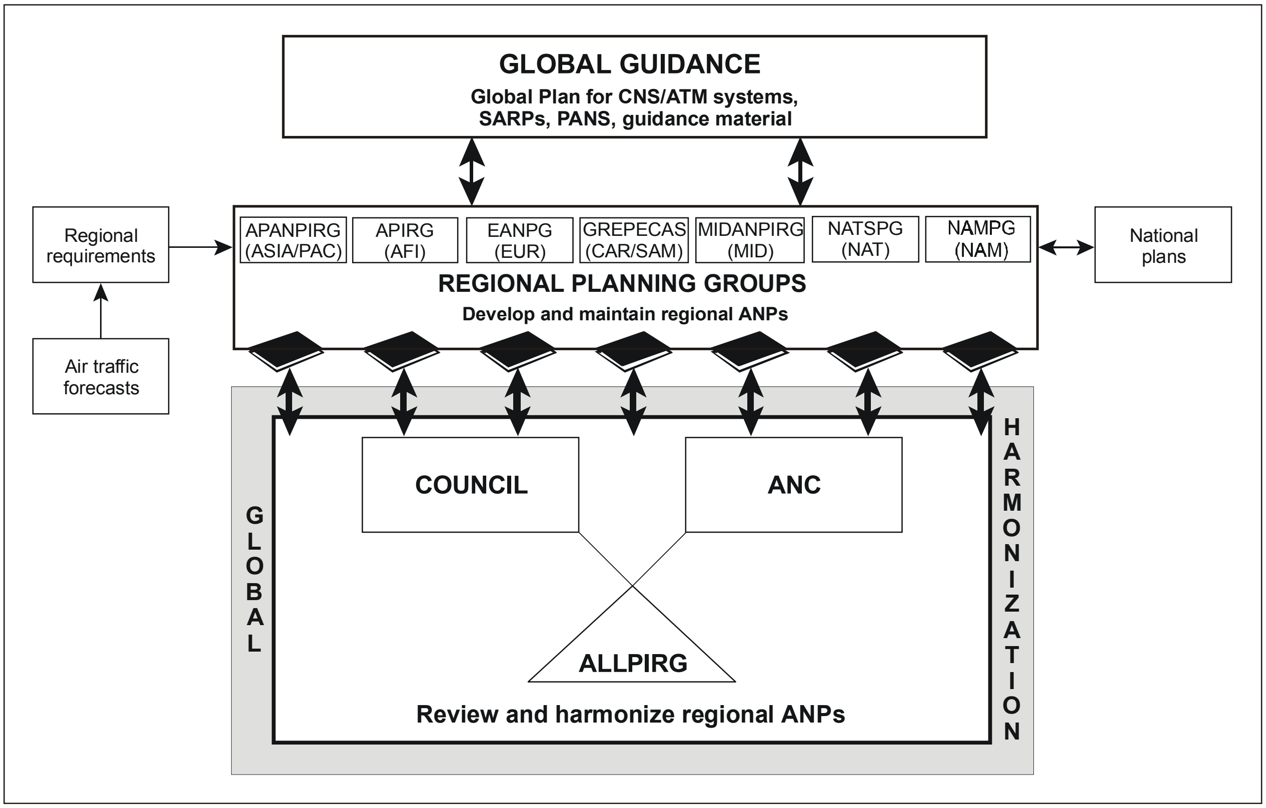

Figure I-2-3. ICAO's planning process in support of global harmonization

with regional requirements and implementation guidelines. It requires ongoing interaction with adjacent States, the regional planning group, and subregional groups to ensure harmonization and interoperability. The national plan document, so structured, will direct the national work programme for a progressive, cooperative and cost-effective implementation of CNS/ATM systems.

CNS/ATM PARTNERS AND TOOLS

2.7 Planning for implementation of facilities and services associated with CNS/ATM systems involves the combined efforts of ICAO, States, users, service providers and industry. These entities are more commonly known as the CNS/ATM partners. The partners conduct their work at several levels with the aim of developing planning documentation which, either directly or indirectly, forms the foundation for development of the regional ANPs. ANPs then list the requirements for facilities and services necessary for the safe and efficient conduct of international civil aviation, and also depict time lines. ICAO provides guidance at the global level in order to ensure harmonization and standardization of regional ANPs.

ACTION PROGRAMME

2.8 The actions required for transition to and implementation of CNS/ATM systems are depicted in Figure I-2-4, which includes guidelines and key activities for the States/regions, users, service providers, manufacturers and ICAO.

RELEVANT ICAO POLICIES ON CNS/ATM

General

2.9 The ICAO Council, at the second meeting of its 141st Session, acting on recommendations contained in the *Report of the Fourth Meeting of the Special Committee for the Monitoring and Co-ordination of Development and Transition Planning for the Future Air Navigation System (FANS Phase II)* (Doc 9623), approved the *Statement of ICAO Policy on CNS/ATM Systems Implementation and Operation* (Appendix A to this chapter refers), which stipulates principles of universal accessibility, sovereignty,

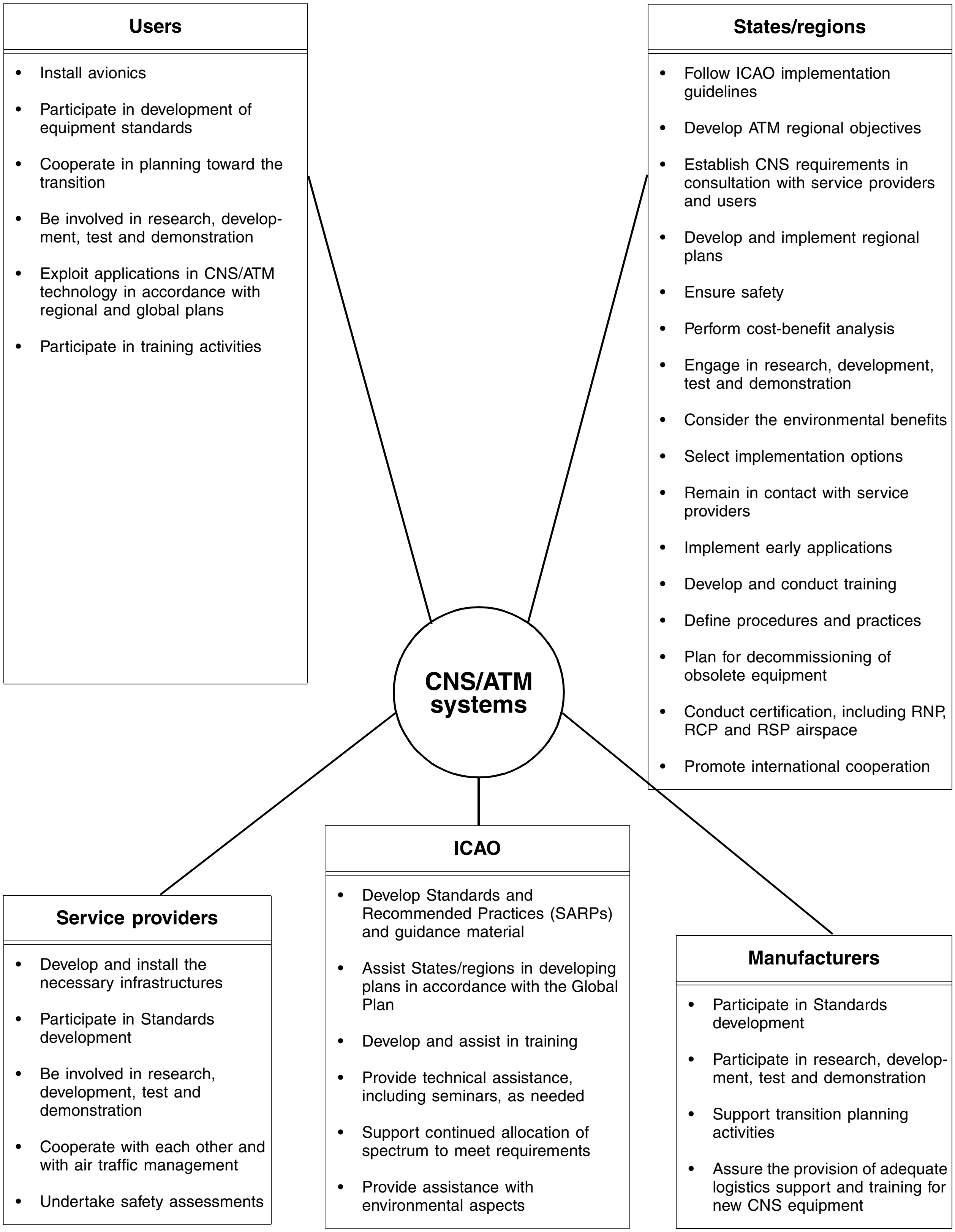

Figure I-2-4. Action programme for CNS/ATM systems

authority and responsibility of Contracting States of ICAO. This statement also sets out the precepts concerning technical cooperation, institutional arrangements, airspace organization and utilization, continuity and quality of service and cost-recovery.

Financial

2.10 As referred to in paragraph 9 of the Statement of ICAO Policy on CNS/ATM Systems Implementation and Operation, the basic policy established by ICAO in the area of airport and air navigation services charges is expressed in Article 15 — Airport and similar charges — of the Chicago Convention. Additional and more detailed policy guidance in the area of air navigation services charges is provided in *ICAO's Policies on Charges for Airports and Air Navigation Services* (Doc 9082). The basic philosophy and principles expressed in the Convention and the Statement on charges for air navigation services are fairness and equity in the determination and sharing of air navigation services costs. The principles contained in the Council Statement address such subjects as the cost basis for air navigation services charges, allocation of air navigation services costs among aeronautical users, air navigation services charging systems, approach and aerodrome control charges, route air navigation services charges, charges for air navigation services used by aircraft when not over the Provider State, and consultation with users regarding charges and air navigation services planning. These principles, by applying to air navigation services in general, thereby also apply to CNS/ATM systems. Hence, no specific reference is made to particular cost-recovery principles that apply exclusively to these systems. CNS/ATM systems will, however, require special considerations insofar as organizational, managerial and cooperative aspects are concerned, as well as with regard to financing, cost and cost-recovery mechanisms.

Technical cooperation

2.11 The 31st ICAO Assembly (Assembly Resolution A32-21 refers) (see Appendix C to this chapter) established the ICAO Objectives Implementation Mechanism as part of the transition to a new policy on technical cooperation, recognizing that the advisory role of ICAO to its Contracting States should be complemented and strengthened at the State and regional levels for the effective implementation of SARPs and ANPs by the ICAO Technical Co-operation Programme. The Council also assigned ICAO a central role in coordinating technical cooperation arrangements for CNS/ATM systems implementation and invited States to provide funds and in-kind assistance where possible (Appendix A to this chapter refers).

2.12 The Assembly encouraged States to make use of, and contribute to, the ICAO Objectives Implementation Mechanism, aimed at consolidating all other funding mechanisms. The ICAO Council directed this new mechanism to pay special attention to assistance requirements of States in CNS/ATM and other areas.

Institutional guidelines and guidelines for transition

2.13 Finally, in developing the original Global Plan for transition to CNS/ATM systems, the FANS Phase II Committee developed a set of institutional guidelines providing guidance for transition to and implementation of CNS/ATM systems. Since the writing of the original Global Plan, the original institutional guidelines have been duly considered by ICAO bodies, overtaken by events or have otherwise become obsolete. Many of these are embodied in the Statement of ICAO Policy on CNS/ATM Systems Implementation and Operation (Appendix A to this chapter refers). Specific guidance on legal and institutional aspects is provided in Part I, Chapter 11, while organizational and international cooperative aspects are covered in Part I, Chapter 12. Transition and implementation guidelines are presented in their respective chapters.

ICAO'S ROLE AND RESPONSIBILITY

2.14 ICAO is the focal point for developing the blueprint for CNS/ATM systems and is also the central coordinating body for its implementation. ICAO has fulfilled and continues to fulfil this role in the following ways:

a) In 1983, the ICAO Council gave the task of studying, *inter alia*, civil applications of satellite systems to the FANS Committee, which developed an air navigation concept for the future;

b) The ICAO Air Navigation Commission, with the support of its panels and the ICAO Secretariat, is carrying out much of the technical work necessary for international standardization, including the development of an ATM operational concept;

c) The international SARPs are continuously reviewed, updated and developed to take into account CNS/ATM systems requirements;

d) PIRGs are developing the regional requirements for facilities and services to be implemented by States;

e) Guidance material on economic and related organizational and managerial issues has been developed;

f) A legal framework for GNSS is being studied; and

g) ICAO's Technical Co-operation Programme is providing assistance to States with such requirements.

2.15 In accordance with its obligations under the Chicago Convention, ICAO continues to carry out its responsibility concerning the adoption and amendment of relevant international SARPs and procedures. These SARPs and procedures are continually being developed, reviewed and updated developed to accommodate CNS/ATM systems requirements. This continuing practice ensures the highest possible degree of uniformity in all matters concerning safety, regularity and efficiency of air navigation. Figure I-2-5 depicts the relationship between the Global Plan, the regional ANPs and the national plans, and also the interaction and relationship between the various ICAO bodies and States.

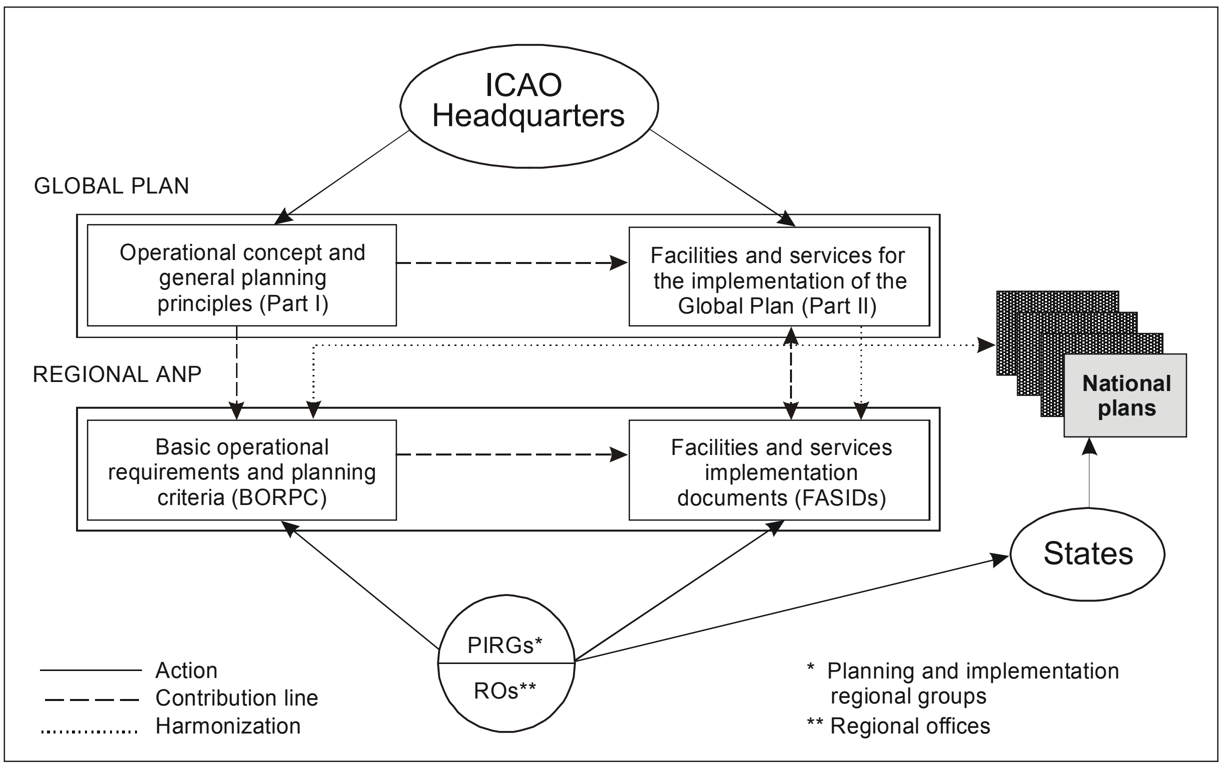

Figure I-2-5. Relationship between the Global Plan, regional ANPs and national plans

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APPENDIX A TO CHAPTER 2

STATEMENT OF ICAO POLICY ON CNS/ATM SYSTEMS IMPLEMENTATION AND OPERATION

Approved by Council (C 141/13) on 9 March 1994

In continuing to fulfil its mandate under Article 44 of the Convention on International Aviation by, *inter alia*, developing the principles and techniques of international air navigation and fostering the planning and development of international air transport so as to ensure the safe and orderly growth of international civil aviation throughout the world, the International Civil Aviation Organization (ICAO), recognizing the limitations of the present terrestrial-based system, developed the ICAO communications, navigation and surveillance/air traffic management (CNS/ATM) systems concept, utilizing satellite technology. ICAO considers an early introduction of the new systems to be in the interest of healthy growth of international civil aviation.

The implementation and operation of the new CNS/ATM systems shall adhere to the following precepts:

1. UNIVERSAL ACCESSIBILITY

The principle of universal accessibility without discrimination shall govern the provision of all air navigation services provided by way of the CNS/ATM systems.

2. SOVEREIGNTY, AUTHORITY AND RESPONSIBILITY OF CONTRACTING STATES

Implementation and operation of CNS/ATM systems which States have undertaken to provide in accordance with Article 28 of the Convention shall neither infringe nor impose restrictions upon States' sovereignty, authority or responsibility in the control of air navigation and the promulgation and enforcement of safety regulations. States' authority shall be preserved in the coordination and control of communications and in the augmentation, as necessary, of satellite navigation services.

3. RESPONSIBILITY AND ROLE OF ICAO

In accordance with Article 37 of the Convention, ICAO shall continue to discharge the responsibility for the adoption and amendment of Standards, Recommended Practices and Procedures governing the CNS/ATM systems. In order to secure the highest practicable degree of uniformity in all matters concerned with the safety, regularity and efficiency of air navigation, ICAO shall coordinate and monitor the implementation of the CNS/ATM systems on a global basis, in accordance with ICAO's regional air navigation plans and global coordinated CNS/ATM systems plan. In addition, ICAO shall facilitate the provision of assistance to States with regard to the technical, financial, managerial, legal and cooperative aspects of implementation. ICAO's role in the coordination and use of frequency spectrum in respect of communications and navigation in support of international civil aviation shall continue to be recognized.

4. TECHNICAL COOPERATION

In the interest of globally coordinated, harmonious implementation and early realization of benefits to States, users and providers, ICAO recognizes the need for technical cooperation in the implementation and efficient operation of CNS/ATM systems. Towards this end, ICAO shall play its central role in coordinating technical cooperation arrangements for CNS/ATM systems implementation. ICAO also invites States in a position to do so to provide assistance with respect to technical, financial, managerial, legal and cooperative aspects of implementation.

5. INSTITUTIONAL ARRANGEMENTS AND IMPLEMENTATION

The CNS/ATM systems shall, as far as practicable, make optimum use of existing organizational structure, modified if necessary, and shall be operated in accordance with existing institutional arrangements and legal regulations. In the implementation of CNS/ATM systems, advantage shall be taken, where appropriate, of rationalization, integration and harmonization of systems. Implementation should be sufficiently flexible to accommodate existing and future services in an evolutionary manner. It is recognized that a globally coordinated implementation, with full involvement of States, users and service providers through, *inter alia*, regional air navigation planning and implementation groups, is the key to the realization of full benefits from the

CNS/ATM systems. The associated institutional arrangements shall not inhibit competition among service providers complying with relevant ICAO Standards, Recommended Practices and Procedures.

6. GLOBAL NAVIGATION SATELLITE SYSTEM

The global navigation satellite system (GNSS) should be implemented as an evolutionary progression from existing global navigation satellite systems, including the United States' global positioning system (GPS) and the Russian Federation's global orbiting navigation satellite system (GLONASS), towards an integrated GNSS over which Contracting States exercise a sufficient level of control on aspects related to its use by civil aviation. ICAO shall continue to explore, in consultation with Contracting States, airspace users and service providers, the feasibility of achieving a civil internationally controlled GNSS.

7. AIRSPACE ORGANIZATION AND UTILIZATION

The airspace shall be organized so as to provide for efficiency of service. CNS/ATM systems shall be implemented so as to overcome the limitations of the current systems and to cater for evolving global air traffic demand and user requirements for efficiency and economy while maintaining or improving the existing levels of safety. While no changes to the current flight information region organization are required for implementation of the CNS/ATM systems, States may achieve further efficiency and economy through consolidation of facilities and services.

8. CONTINUITY AND QUALITY OF SERVICE

Continuous availability of service from the CNS/ATM systems, including effective arrangements to minimize the operational impact of unavoidable system malfunctions or failure and achieve expeditious service recovery, shall be assured. Quality of system service shall comply with ICAO Standards of system integrity and be accorded the required priority, security and protection from interference.

9. COST-RECOVERY

In order to achieve a reasonable cost allocation between all users, any recovery of costs incurred in the provision of CNS/ATM services shall be in accordance with Article 15 of the Convention and shall be based on the principles set forth in *ICAO's Policies on Charges for Airports and Air Navigation Services* (Doc 9082), including the principle that it shall neither inhibit nor discourage the use of the satellite-based safety services. Cooperation amongst States in their cost-recovery efforts is strongly recommended.

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APPENDIX B TO CHAPTER 2

EXTRACT FROM THE ASSEMBLY RESOLUTIONS IN FORCE (AS OF 2 OCTOBER 1998) (DOC 9730) ASSEMBLY RESOLUTION A31-6

A31-6: Consolidated statement of continuing ICAO policies and practices related to communications, navigation and surveillance/air traffic management (CNS/ATM) systems

Whereas it is considered desirable to consolidate Assembly resolutions on the Organization's policies and practices related to CNS/ATM in order to facilitate their implementation and practical application by making their text more readily available and logically organized;

The Assembly:

1. *Resolves* that the Appendices attached to this resolution constitute the consolidated statement of continuing ICAO policies and practices related to CNS/ATM, up to date as these policies exist at the close of the 31st Session of the Assembly;

2. *Resolves* to continue to adopt at each ordinary session of the Assembly, for which a Technical Commission is established, a consolidated statement of continuing ICAO policies and practices related to CNS/ATM; and

3. *Declares* that this resolution supersedes A29-8 and A29-9.

APPENDIX A *(to Assembly Resolution A31-6)*

General Policy

Whereas ICAO is the only international organization in a position effectively to coordinate global CNS/ATM activities;

Whereas the ICAO CNS/ATM systems should be utilized to serve the interests and the objectives of civil aviation throughout the world;

Whereas Contracting States should have equal rights to benefit from global systems incorporated within the ICAO CNS/ATM systems;

Considering the Statement of ICAO Policy on CNS/ATM Systems Implementation and Operation developed and adopted by the ICAO Council on 9 March 1994;

The Assembly:

1. *Resolves* that nothing should deprive a Contracting State from its right to benefit from the ICAO CNS/ATM systems or cause discrimination between provider and user States;

2. *Resolves* that States' sovereignty and borders should not be affected by the ICAO CNS/ATM systems implementation;

3. *Urges* that provisions and guidance material relating to all aspects of the ICAO CNS/ATM systems should be sought and developed through the convening of adequate meetings, conferences, panels and workshops with the participation of Contracting States; and

4. *Urges* that the proposed provisions covering all aspects of the ICAO CNS/ATM systems be presented to all Contracting States well in advance to give them enough opportunity to prepare themselves as far as practicable.

APPENDIX B *(to Assembly Resolution A31-6)*

Harmonization of the implementation of the ICAO CNS/ATM systems

Considering the international character of civil aviation and the regional interactions of air navigation services;

Considering Recommendations 4/5, 6/2, 7/1, 8/4 and 8/5 of the Tenth Air Navigation Conference, Recommendations 4/4 and 4/5 of the third meeting of the Special Committee for the Monitoring and Coordination of Development and Transition Planning for the Future Air Navigation System (FANS Phase II) and Recommendation 4/4 of the fourth meeting of the FANS (Phase II) Committee;

Considering that these recommendations have been noted or approved by the Council of ICAO, which has instructed the Secretary General of ICAO to take all appropriate measures;

Recognizing the role which regions must play in the planning and implementation of the ICAO CNS/ATM systems;

Conscious of the delay which certain regions could experience in the transition to these systems;

Noting with satisfaction the trials and demonstrations programmes and the progress being achieved by certain regions with regard to these systems;

Noting that it has not been possible in some areas to initiate such trials and demonstrations programmes;

Believing that the contribution of all regions would guarantee a better evaluation of the trials and would favour the evolution of the ICAO CNS/ATM systems;

Noting that economic and institutional issues, in particular cost/benefit analysis, and facility financing, cost recovery and cooperative aspects, need to be addressed by States individually and/or collectively;

Noting that for an early realization of benefits to users and for globally coordinated and harmonious CNS/ATM systems implementation certain States will require technical and financial assistance and recognizing the statement concerning the central role ICAO shall play in coordinating technical cooperation arrangements as well as in facilitating the provision of assistance to States with regard to the technical, financial, managerial, legal and cooperative aspects of implementation;

The Assembly:

1. *Calls upon* States, in a position to do so, to spare no effort in cooperating and facilitating the execution of the research, development, trials and demonstrations (RDT&D) programme in close cooperation with States with limited resources;

2. *Invites* the cooperation of the international organizations concerned, users and service providers for the execution of the above-mentioned programme in favour of States with limited resources;

3. *Requests* the Council, as a matter of high priority within the budget adopted by the Assembly, to:

a) ensure that the resources necessary for the implementation of the following recommendations are made available:

   1) Recommendations 4/5, 6/2, 7/1, 8/4 and 8/5 of AN-CONF/10;

   2) Recommendations 4/4 and 4/5 of FANS(II)/3;

   3) Recommendation 4/4 of FANS(II)/4; and

b) ensure that adequate resources are made available to the ICAO Regional Offices, particularly those which are accredited to the developing States, taking into account the increased support they will be called upon to provide to the regional planning and implementation groups, which are the main bodies for the regional planning of the transition to the ICAO CNS/ATM systems;

4. *Further requests* the Council to urge States, international organizations and financial institutions to mobilize resources in order to assist States requiring technical cooperation in the planning and implementation of the ICAO CNS/ATM systems;

5. *Urges* the Council to continue considering without delay the economic, institutional, legal and strategic aspects related to the implementation of the ICAO CNS/ATM systems.

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APPENDIX C TO CHAPTER 2

EXTRACT FROM THE ASSEMBLY RESOLUTIONS IN FORCE (AS OF 2 OCTOBER 1998) (DOC 9730) ASSEMBLY RESOLUTION A32-21

A32-21: Transition to a new policy on Technical Co-operation

Whereas the ICAO Technical Co-operation Programme has been in operation since 1951 and has made invaluable contributions to international civil aviation;

Whereas technical cooperation has been established as a permanent priority activity of ICAO but should be further integrated with the Organization's other activities;

Whereas the growth and improvement of civil aviation contributes significantly to the economic development of States;

Whereas ICAO, through its Technical Co-operation Programme, effectively assists States in advancing their civil aviation;

Whereas the persistent decline of funding from the United Nations Development Programme (UNDP) continues to affect the Technical Co-operation Programme;

Whereas, prior to Resolution A29-20, ICAO's Technical Co-operation Programme did not have financial support from the Regular Programme in the case of budget shortfalls;

Whereas the advisory/regulatory role of ICAO to Contracting States should be complemented and strengthened at the country and regional levels for the effective implementation by the Technical Co-operation Bureau of ICAO SARPs and ANPs, as well as ICAO's CNS/ATM and Flight Safety Oversight Programme;

Whereas the 31st Session of the Assembly endorsed the new policy on technical cooperation based on the progressive implementation of the core staff concept, the progressive integration of the TCB into the organizational structure, and the establishment of the ICAO Objectives Implementation Funding Mechanism, as well as the objectives of the new policy which emphasize the global implementation of SARPs and ANPs and the development of civil aviation master plans; and

Whereas the implementation of the elements of the new policy on technical cooperation has already contributed and will continue to contribute to minimize staff costs and maximize the Technical Co-operation Programme and its implementation, and substantially improve the financial situation of the Technical Co-operation Bureau;

The Assembly:

1. *Notes* with satisfaction the progress made in the progressive implementation of the core staff and the related integration of the Technical Co-operation Bureau into the Organization's structure;

2. *Urges* the Secretary General to further promote ICAO's Technical Co-operation Bureau and its role in the implementation of ICAO's SARPs including the CNS/ATM and Flight Safety Oversight Programmes; and

3. *Encourages* Contracting States to make use of the Technical Co-operation Programme of ICAO and to contribute to the ICAO Objectives Implementation Funding Mechanism of which all funds are mainly intended for SARPs implementation including the Flight Safety Oversight and the CNS/ATM Programmes.

4. *Approves* the following transitional measures for implementation during the 1999-2001 Triennium:

a) In case of a budget shortfall, the Regular Programme budget will continue to augment the support cost income earned from projects to support the Technical Co-operation Programme according to the proposal contained in the Programme Budget for the Organization for 1999, 2000 and 2001.

b) The Council and the Secretary General will further implement the core staff concept by attrition, restructuring and staff transfer.

c) The Council and the Secretary General will adopt further measures to integrate the Technical Co-operation Bureau into the Organization's structure;

5. *Directs* the Council to report to the next ordinary session of the Assembly regarding the plan for further integration and the measures taken in the meantime, and to prepare for its consideration a consolidated Resolution regarding all technical cooperation activities and programmes; and

6. *Decides* that this Resolution replaces and supersedes Resolution A31-14.

Chapter 3

GLOBAL PLANNING METHODOLOGY

REFERENCES

Statement of Basic Operational Requirements and Planning Criteria for Regional Air Navigation Planning (Regional Air Navigation Plans)
Air Traffic Services Planning Manual (Doc 9426)
Automatic Dependent Surveillance (Circular 226)
Methodology for the Derivation of Separation Minima Applied to the Spacing between Parallel Tracks in ATS Route Structures (Circular 120)

INTRODUCTION

3.1 As traffic volumes grow worldwide, the demands on the ATS provider in a given airspace increase, as do the complexities of air traffic management. The number of flights unable to follow optimum flight paths also increases with an increase in traffic density. This creates pressure to upgrade the level of ATS by, *inter alia*, reducing separation minima.

3.2 Implementation of CNS/ATM systems will enhance capacity to meet the increasing demand, while producing additional benefits in the way of more efficient flight profiles and increased levels of safety. The potential for new technologies to significantly reduce service costs, however, will require new arrangements in the provision of services and changes in air traffic management procedures.

3.3 This chapter of the Global Plan provides instructions on how to begin the process of identifying ATM requirements, on the basis of identified homogeneous ATM areas and major traffic flows and routing areas, followed by the determination of regional and global CNS system elements needed to meet the ATM requirements.

HOMOGENEOUS ATM AREAS AND MAJOR TRAFFIC FLOWS

Homogeneous ATM area

3.4 **Homogeneous ATM area**. An airspace with a common air traffic management interest, based on similar characteristics of traffic density, complexity, air navigation system infrastructure requirements or other specified considerations wherein a common detailed plan will foster the implementation of interoperable CNS/ATM systems.

Note.— Homogeneous ATM areas may extend over States, specific portions of States, or groupings of States. They may also extend over large oceanic and continental areas. They are considered areas of shared interest and requirements.

3.5 The method of identifying homogeneous ATM areas involves consideration of the varying degrees of complexity and diversity of the worldwide air navigation infrastructure. Based on these considerations, it is considered that planning could best be achieved, at the global level, if it were organized based on ATM areas of common requirements and interest, taking into account traffic density and the level of sophistication required (Figure I-3-1 offers several examples).

Major traffic flows

3.6 **Major traffic flow**. A concentration of significant volumes of air traffic on the same or proximate flight trajectories.

Note.— Major traffic flows may cross several homogeneous ATM areas with different characteristics.

3.7 **Routing area.** An area encompassing one or more major traffic flows, defined for the purpose of developing a detailed plan for the implementation of CNS/ATM systems and procedures.

Note.— A routing area may cross several homogeneous ATM areas with different characteristics. A routing area specifies common interests and requirements among underlying homogeneous areas, for which a detailed plan for the implementation of CNS/ATM systems and procedures either for airspace or aircraft will be specified.

3.8 The basic planning parameter is the number of aircraft movements that must be provided with ATM

Area of routing (AR)	Traffic flows	FIRs involved	Type of area covered	Remarks
Asia/Pacific (ASIA/PAC) Regions				
ARx	Asia/Australia and Africa	Bangkok, Bombay, Colombo, Jakarta, Kuala Lumpur, Madras, Malé, Melbourne, Singapore, Yangon, [and African FIR/UIRs]	Oceanic low density	Major traffic flow AFI/ASIA/MID
ARx	Asia (Indonesia north to China, Japan and the Republic of Korea), Australia/New Zealand	Auckland, Bali, Bangkok, Beijing, Biak, Brisbane, Guangzhou, Hanoi, Ho-Chi-Minh, Hong Kong, Honiara, Jakarta, Kota Kinabalu, Kuala Lumpur, Manila, Melbourne, Nadi, Naha, Nauru, Oakland, Phnom-Penh, Port Moresby, Shanghai, Singapore, Taegu, Taipei, Tokyo, Ujung Pandang, Vientiane, Wuhan, Yangon	Oceanic high density	Major traffic flow ASIA/PAC
ARx	Asia and North America via the Russian Far East and the Polar Tracks via the Arctic Ocean and Siberia	Anchorage, Beijing, Guangzhou, Hong Kong, Pyongyang, Russian Far East of 80E, Shanghai, Shenyang, Taegu, Tokyo, Wuhan and Ulaanbaatar, [and Canadian FIRs]	Continental low density/ Continental high density	Major traffic flow ASIA/EUR/ NAM/NAT

Figure I-3-1. Examples of major international traffic flows

services. Estimates and forecasts of annual aircraft movements over the planning period are required for high-level planning. Forecasts of aircraft movements in peak periods, such as during a particularly busy hour, are needed for detailed planning. Additionally, appropriate civil/military coordination and consideration of special use airspace (SUA) is required. This coordination should take place during the planning stage to ensure a realistic chance of implementation and in the tactical phase to allow for a flexible use of airspace through the dynamic design and activation of SUA. The principal data sources for current or historic aircraft movements are the official airline guides: World Airways Guide, ICAO's Traffic by Flight Stage Statistics and En-route Facility Statistics, and specific statistical information for flight information regions, which can be obtained from relevant area control centres (ACCs).

3.9 The ICAO Secretariat, in cooperation with the International Air Transport Association (IATA), is progressively developing estimates of current traffic volumes for specific areas, which consist of major international route groups. This information is being designed to assist with planning at the global level. Additionally, traffic forecasting groups are being established by ICAO in order to provide the PIRGs with comprehensive databases and forecasts of traffic flows for groups of routes for the detailed planning process.

STATEMENT OF BASIC OPERATIONAL REQUIREMENTS AND PLANNING CRITERIA FOR REGIONAL AIR NAVIGATION PLANNING

3.10 While the Global Plan provides the framework to be followed in the planning process, along with the latest information and planning criteria for development of emerging and future systems, the Statement of Basic

Operational Requirements and Planning Criteria for Regional Air Navigation Planning (approved by the Air Navigation Commission on 17 June 1999) provides the necessary guidance on the preparation of the regional air navigation plan for air navigation facilities, services and procedures recommended for the area, to meet the requirements of all international civil aircraft operations during at least the next five-year period, taking due account of the long-term planning and implementation strategies regarding CNS/ATM systems and as portrayed in the Global Plan, and possible effects on adjacent regions.

PLANNING METHODOLOGY

3.11 The basis for developing a global, integrated ATM system will be an agreed-to structure of homogeneous ATM areas and major traffic flows/routing areas. These areas and flows tie together the various elements of the worldwide aviation infrastructure into a global system. The Global Plan lists several of these. Further identification and analyses of these areas and traffic flows are being carried out by PIRGs in collaboration with the aircraft operators, reflecting the latter's requirements.

3.12 The planning process for any particular region should begin with the identification of specific homogeneous ATM areas and major traffic flows, based on user needs, followed by the development of an ATM plan for the region and, eventually, for each State. Considering the communications, navigation and surveillance elements of the CNS/ATM systems infrastructure to support air traffic management, it is necessary for each region or State to first ascertain the ATM objectives for a given homogeneous ATM area or major traffic flow/routing area. The ATM operational concept, expected to be available by mid-2002, will describe how the global ATM system should operate and will help to determine the ATM objectives. An operational analysis should be performed in order to determine which CNS and other technical and automation elements are needed to fulfil the ATM objectives. The operational analysis and the ATM operational concept therefore complement each other. (An approach to conducting an operational analysis is presented at paragraph 3.17.) Finally, an assessment should be made of the technical elements and implementation options that would most appropriately and cost-effectively meet the ATM objectives for that area or traffic flow/routing area.

3.13 Based on the above, PIRGs are responsible for the integration and harmonization of CNS/ATM systems plans for their various regions, while ICAO, through this Global Plan, ALLPIRG meetings, worldwide conferences, and an interregional coordination mechanism, carries out interregional coordination to ensure global compatibility, harmonization and seamlessness of the systems. At all stages of the planning process, coordination with aircraft operators must be carried out in order to fully address user requirements.

3.14 Each regional planning group will develop its own work structure for accomplishing the work associated with the step-by-step approach listed hereunder. In some cases, an already established working group or CNS/ATM subgroup may be in a suitable position to accomplish the work; in other cases, specific task forces or subgroups will need to be established. Figure I-3-6 depicts a flow diagram, illustrating the planning methodology contained in 3.15.

3.15 The step-by-step approach for planning ATM requirements and CNS infrastructure is as follows:

Step 1. Identify homogeneous ATM areas and/or major traffic flows.

Step 2. List the ICAO region(s), flight information region(s) and State(s) involved in the homogeneous ATM areas and/or major international traffic flows (Figure I-3-1 refers).

Step 3. Carry out air traffic forecasts and ascertain airspace user needs.

Step 4. Perform an operational analysis of the current infrastructure for the areas identified in Step 2 in terms of, *inter alia*:

a) ATM limitations and shortcomings;

b) separation standards; and

c) CNS availability.

Step 5. Determine the ATM objectives for the areas identified in Step 2 in terms of the required total systems performance (RTSP), using as the basis the guidance material contained in the operational concept document *(operational analysis)*.

Step 6. Establish CNS and other technical and automation requirements necessary to support the desired ATM objectives identified in Step 5 *(operational analysis)*.

Step 7. Analyse the benefits/improvements resulting from Steps 5 and 6 in order to establish *(operational analysis)*:

a) costs/benefits;

b) relative priority;

c) expected performance improvements; and

d) implementation dates of the various ATM objectives and CNS facilities for each of the homogeneous ATM areas and major traffic flows/routing areas. (Chapters 5, 6, 7 and 8, and Figures I-3-2 to I-3-5 of this chapter refer).

Step 8. Considering the many technical solutions and implementation options available, repeat as necessary Steps 5, 6 and 7 to determine the most appropriate solution *(operational analysis).*

Step 9. Develop an ATM implementation plan based on the outcome of steps 1 through 8 above using as the basis the guidance material contained in the operational concept document and the results of the operational analysis. A safety assessment should demonstrate that any new systems, or changes to the present systems, will achieve an acceptable level of safety.

Step 10. Examine the possibilities of funding the implementation of the CNS/ATM systems infrastructure for States requiring financial assistance.

Step 11. Determine the means and methods of cost-recovery.

Step 12. Establish a framework to interface with all the CNS/ATM partners on a continuing basis to ensure the harmonious and integrated implementation of CNS/ATM systems in homogeneous areas and/or major international traffic flows.

3.16 The FASIDs of the regional ANPs should be developed with full consideration of the high-level guidance provided in Part I and the step-by-step approach described here and conceptualized in the tables in Part II of the Global Plan. As the ATM operational concept and the associated RCP*, required navigation performance (RNP), RSP* and RTSP* mature, they should be integrated into the planning process so that further development can take place. Planning and implementation should therefore be seen as a continuing, evolving and maturing process.

* Emerging concept or technology — consensus still to be reached.

THE OPERATIONAL ANALYSIS

3.17 An operational analysis is a necessary part of ATM implementation planning which leads to the selection of solutions which will be the most effective in fulfilling the ATM objectives. The ICAO global ATM operational concept will describe how the global ATM system should operate and will also help to identify the facilities and services required to fulfil the global objectives. The operational analysis and the ATM operational concept complement each other. Steps 4 through 8 of the step-by-step approach to planning described in 3.15 are centred on the operational analysis outlined below.

3.18 Given the difficulty encountered in attempting to define long-term operational requirements for various large air navigation system projects, the development of operational requirements on the basis of an operational analysis is not an exact science. Looking too far into the future and attempting to incorporate definitive needs is difficult and prone to error in light of the evolving nature of ATM systems and the rapidly changing technological solutions. It is more appropriate, therefore, to address more immediate requirements and ensure that a mechanism is available to extend the implementation process into the future.

3.19 An analysis is appropriate when perceived symptoms indicate a deficiency in the air traffic services being provided; when additional demands from users require such services to be expanded; or when circumstances indicate that a need or opportunity exists to improve effectiveness, efficiency or economy within the ATM system. It is generally accepted that with the introduction of CNS/ATM systems, new opportunities for improving ATM have emerged and will continue to emerge. Therefore, a thorough operational analysis should be carried out, followed by the development of ATM implementation plans, prior to implementing new ATM systems.

3.19.1 **Getting started**. The operational analysis begins with the identification of a need, problem or opportunity by studying the existing set of circumstances.

3.19.2 **Definition of the ATM role and objectives**. The role of ATM in the context of the systems or services being studied is defined, and the ATS policies, objectives or tasks that are pertinent to the analysis are specified.

3.19.3 **Description of the current system**. By referring to air navigation system (ANS) documents for the system under study, the role that the system is intended to fulfil is outlined, along with the tasks it is intended to support. A list of objectives that the system should sustain by its currently specified performance capability is then compiled.

3.19.3.1 The current system's performance is established in relation to its capability to satisfy the identified needs.

3.19.3.2 The operational deficiencies that prevent the resolution of problems are identified.

3.19.3.3 Performance limitations that constrain the current system's ability to take advantage of the existing opportunity are detailed.

3.19.3.4 Interactions and interfaces between the system under study and others are examined.

3.19.4 **Evaluation**: **Current system against present requirements**. A comparison is made of the existing system's capability against the present requirements. The following questions should be answered:

a) Does the current system do the present job adequately?

b) Does its capability enable the allocation of additional tasks to satisfy the identified needs?

3.19.4.1 If the answers are "yes", longer-term analysis can be undertaken. However, if either answer is "no", it is clear that the current system is deficient and should be modified or replaced to remedy its shortcomings, if possible. Any modification must address the changes necessary to satisfy the needs, or to resolve the identified problems and their causes, and should not merely attempt to minimize or alleviate the associated symptoms.

3.19.5 **Listing of future objectives and system requirements**. The future objectives and requirements that must be addressed are then listed, and the operational characteristics that a system must possess to support these are derived. Section 4 of the operational concept document describes future air traffic scenarios while Section 3 describes technical solutions which may be needed to fulfil future requirements.

3.19.6 **Evaluation: Current system against future requirements.** The capability of the existing system to support the identified future objectives and to satisfy their associated requirements is investigated, and the current system's capacity to perform the future job is determined.

3.19.6.1 If the current system has already been shown to meet present requirements and has the ability to satisfy future requirements, the analysis stops because there is no need to satisfy, no problem to resolve, and no opportunity will be missed.

3.19.6.2 Analysts must avoid the tendency to develop a solution and then invent a need, problem or opportunity to which the solution can be applied.

3.19.6.3 If the current system cannot satisfy the present requirements and/or the future requirements, the exercise continues.

3.19.7 **Statement of operational requirements**. From the previous steps it becomes possible to prepare a statement of operational requirements which describes, in broad terms, the need for a new or modified system and addresses the capability such a system must have.

3.19.7.1 An operational requirement may be defined as a statement of the operational attributes of a system needed for the effective and/or efficient provision of air traffic services to users. An operational requirement is not a description of "how" a need is to be met. Furthermore, solutions to problems will not always be technical in nature. It may be that the requirement will be met by appropriate procedural, training or staffing actions. However, when technical solutions are required, close coordination between operational and technical experts is essential if the optimum solution is to be found.

3.19.7.2 The described capability, which is expanded upon below, is that which is necessary to satisfy the need, to resolve the problem, or to take advantage of the opportunity which would support the objectives and ensure that the role of ATS is fulfilled.

3.19.8 **Establishing compliance criteria.** Compliance criteria, which are high-level "musts" describing the basic operational characteristics of the system needed, are then generated. These criteria outline essential performance capabilities that proposed solutions must possess. Later, alternatives will be rated against these operational absolutes. For example, the communications systems performance requirement parameters specified for ICAO ATS data link applications state, ". . . the probability that a message will be misdirected will be equal to or less than 10^{-7}."

3.19.9 **Listing and describing alternatives.** Next, all reasonable alternatives are listed and described, including procedural change and the possibility of doing nothing. At this point descriptions need not be extremely detailed. For example, if a potential solution stems from the same equipment family as a primary radar system, it is necessary only to describe in general terms how a primary radar system operates and not how all the different types of primary radar function.

3.19.9.1 This step will need to include a "market search" of potential solutions available as commercial off-the-shelf (COTS) products which have been developed in response to similar problems identified by other administrations. In the past, the "custom-built" solution has normally proven to be the better method; however, as the harmonization of ATC systems across international boundaries increases due to improved cooperation, this may no longer be the case.

3.19.10 **Selection of preferred option.** Each alternative must be compared against each compliance criterion to determine the preferred option. On the initial assessment, any alternative must receive a "yes" [it satisfies each criterion], or a qualified "yes" [it satisfies each criterion with certain limitations], to be considered further.

3.19.10.1 If any alternative receives a "no" [it does not satisfy a criterion], that choice is no longer considered unless every other alternative fails, i.e. gets at least one "no". If this happens, the options may be reviewed to select the option with the lowest "no" count. At this point the chosen option will, of necessity, be a compromise. Any alternative that does not satisfy all criteria cannot, by definition, fulfil the entire need, resolve the entire problem, or take full advantage of the opportunity. Some undesirable effects will continue. Therefore, the solution must be the option which most effectively responds to the operational issues being addressed.

3.19.10.2 During the operational analysis, alternatives should not be evaluated based on costs. If the consideration of money enters the decision-making process too soon, it may cause a bias towards a less expensive solution which may not attain the desired operational results. Costs will be addressed during the cost-benefit analysis and during the efficiency analysis when the best technical solution will be found to address the operational concerns considering technical, financial and other issues. It may become evident that potential technical solutions need not be pursued as it becomes apparent that the cost of implementation cannot be supported.

3.19.10.3 Where COTS products appear to provide possible solutions to the problems being addressed, the option of developing a new system will usually carry a lesser weight unless the cost of the COTS product is clearly exorbitant. This should rarely be the case. However, the costs of "modifying" COTS products to meet specific requirements may ultimately cost more than the build-from-scratch option.

3.19.11 **Conclusions, recommendations, preferred options.** The conclusions and recommendations from all previous steps, ending with the preferred options based on operational effectiveness, are finally presented to the appropriate level of management for action. Senior management must agree that a problem or opportunity exists, and approve the resources to develop the detailed and accurate costing data needed.

3.19.12 **Development of operational performance requirements.** The final step in the analysis process is the description of the complete operational capacity of the proposed solution. For example, the description of a data link system which will handle inter-facility messages must include clear performance requirements for the definitions of the types of messages to be exchanged, how many in a given time period, at what times of the day, between which agencies, internal and external, acceptable error rates, system availability and reliability, etc. Later, these operational performance requirements will be used to assist in evaluating the operational acceptability of technical alternatives proposed as candidates for meeting the operational need.

3.19.13 **Prototyping and simulation.** Prototyping and simulation can prove extremely valuable at this point in the analysis as a means of validating the operational concepts being defined, ensuring the operational acceptability of competing computer/human interfaces (CHI) operational procedures, and clarifying the requirement in concrete terms. This approach mitigates the possibility of technical misinterpretations of the operational need and thus prevents the final delivery of a system or component which does not reflect the operational intent.

3.19.13.1 The cycle of analysis described above may need to be repeated in an iterative fashion following the choice of a proposed technical solution to a problem to ensure that the operational needs are met prior to embarking on the implementation phase.

AIR TRAFFIC MANAGEMENT IMPLEMENTATION															
Area of routing	Regions/States affected	ATM objective	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
AR ...	ICAO region	Objective													
	States														
AR ...	ICAO region	Objective													
	States														

Figure I-3-2. Reproduction of tables from Part II

AIR TRAFFIC MANAGEMENT REQUIREMENTS (COMMUNICATIONS)															
Area of routing	Regions/States affected	System elements	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
AR ...	ICAO region	Element													
	States														
AR ...	ICAO region	Element													
	States														

Figure I-3-3. Reproduction of tables from Part II

AIR TRAFFIC MANAGEMENT REQUIREMENTS (NAVIGATION)															
Area of routing	Regions/States affected	System elements	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
AR ...	ICAO region	Element													
	States														
AR ...	ICAO region	Element													
	States														

Figure I-3-4. Reproduction of tables from Part II

AIR TRAFFIC MANAGEMENT REQUIREMENTS (SURVEILLANCE)															
Area of routing	Regions/States affected	System elements	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
AR ...	ICAO region	Element													
	States														
AR ...	ICAO region	Element													
	States														

Figure I-3-5. Reproduction of tables from Part II

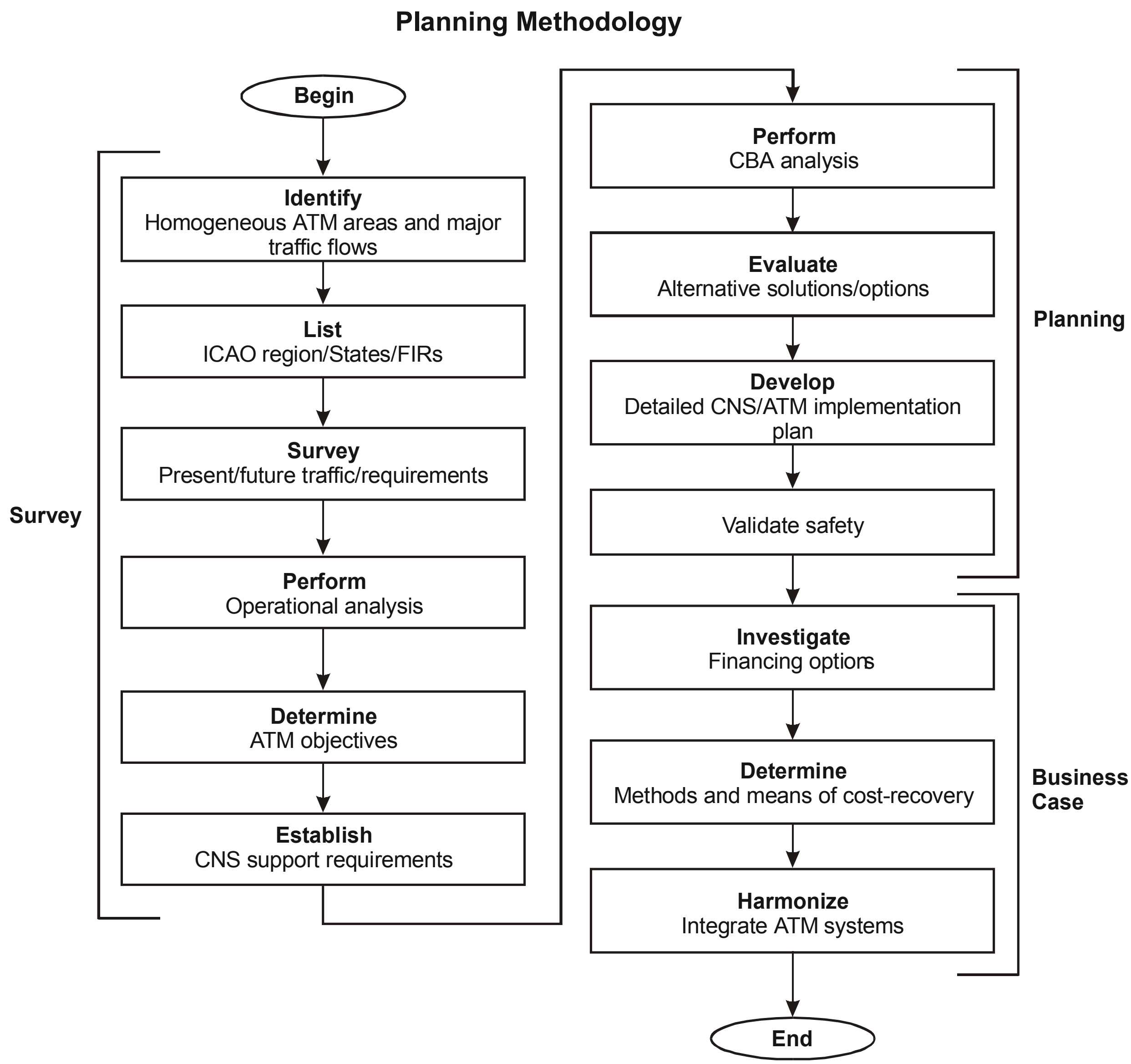

Figure I-3-6. Planning methodology

Chapter 4

AIR TRAFFIC MANAGEMENT

REFERENCES

Annex 2 — *Rules of the Air*
Annex 11 — *Air Traffic Services*
Procedures for Air Navigation Services — Air Traffic Management (PANS-ATM, Doc 4444)
Manual on Airspace Planning Methodology for the Determination of Separation Minima (Doc 9689)
Manual on Required Navigation Performance (RNP) (Doc 9613)
Manual of Air Traffic Services Data Link Applications (Doc 9694)
Manual on Implementation of a 300 m (1 000 ft) Vertical Separation Minimum Between FL 290 and FL 410 Inclusive (Doc 9574)
Air Traffic Services Planning Manual (Doc 9426)
Automatic Dependent Surveillance (Circular 226)
Simultaneous Operations on Parallel or Near-Parallel Instrument Runways (SOIR) (Circular 207)
Methodology for the Derivation of Separation Minima Applied to the Spacing between Parallel Tracks in ATS Route Structures (Circular 120)
Human Factors Guidelines for Air Traffic Management (ATM) Systems (Doc 9758)

INTRODUCTION

4.1 Air traffic management is the aggregation of the airborne functions and ground-based functions (air traffic services, airspace management and air traffic flow management) required to ensure the safe and efficient movement of aircraft during all phases of operations.

LIMITATIONS OF THE ATM SYSTEM (CIRCA 2001)

4.2 The conventional airspace organization of flight information regions and their supporting infrastructure of ATS routes and ground-based facilities and services has been increasingly based on international requirements, due in large part to the ICAO regional planning process. Where this is not the case, fragmentation of the airspace and a diversity of national systems prevents an optimum use of the airspace. Additionally, there are limitations to the amount of traffic that ATC systems can handle, especially on rand om routings, without increasing levels of automation to assist with conflict detection and resolution. For these reasons, aircraft must plan their flights along ATS routes and be channelled, to a certain degree, in order for ATC to keep aircraft safely separated from each other.

Limitations of the current approach to ATM by phase of flight

En-route operations

4.3 The existing ATS route structure often involves mileage penalties, compared to the most economic routes, which may be great circle routes but which also take into account wind, temperature and other factors such as weight of the aircraft, charges and safety. This often results in a concentration of traffic flows at major intersections, which can lead to a reduction in the number of optimum flight levels being available. A lack of uniformity in ATC procedures and separation minima around the world, due to differences and limitations in ATC capabilities, places additional constraints on the aircraft operators. Furthermore, aircraft are often unable to take advantage of advanced on-board capabilities because the ATC system is unable to support their use. A lack of coordination among States in the development of ground ATM systems has resulted in additional problems. Examples include inconsistent separation minima in radar and non-radar airspace and operation at less than optimum flight levels in oceanic airspace due to communications deficiencies.

Terminal control area operations

4.4 Although terminal airspace is usually provided with better surveillance and communications capabilities, it differs from en-route airspace primarily because of the higher traffic densities and greater complexity of traffic flow. Arriving and departing aircraft share the terminal airspace, and also aircraft having widely differing performance characteristics operate to the same or closely spaced runways. Current separation requirements sometimes prevent full use of available capacity at busy airports. Automation to manage departures and arrivals efficiently is not always available, and on-board automation is therefore under-utilized. Published arrival and departure routes are sometimes inflexible and result in indirect routings. Noise abatement and environmental procedures can impose further restrictions on terminal area operations.

Airport surface movement area

4.5 The ground control of aircraft is conducted through radar or visual means. Automation to support surface movement guidance and control systems (SMGCS) of aircraft and vehicles is lacking, and many major airports operate in near gridlock conditions during periods of peak demand. Coordination between ATM and ramp and taxi areas will require standardization and harmonization for the gate-to-gate operations* envisaged in future ATM systems. In low-visibility conditions, movements are severely restricted and there is increased risk of runway incursion or violation of instrument landing system (ILS) critical or sensitive areas.

GLOBAL ATM

4.6 The planning for implementation of CNS technologies is well under way in varying degrees in the ICAO regions. It is necessary that the transition be focused with a clear concept of how to integrate those elements into a coherent and seamless global ATM system. The global ATM system must be developed and organized to overcome the limitations listed above 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 civil aviation community.

Implementation goals and strategies of global ATM

4.7 The primary goal of an integrated, global ATM system is to safely meet the expectations of the ATM partners. For example, the ATM system should enable aircraft operators to meet their planned times of departure and arrival, to the extent possible, and adhere to their preferred flight profiles with minimum constraints and no compromise to safety. To accomplish this goal, the new CNS technologies must be fully exploited through international harmonization of ATM Standards and procedures. From the aircraft operator's point of view, it is desirable to equip aircraft operating internationally with a minimum set of avionics usable everywhere. Additionally, many of the expected service improvements cannot be meaningfully implemented by one State, but must be implemented in contiguous regions. Therefore, the ATM regional concept of providing ATM over expanded areas must be pursued. The goals of the future ATM system are summarized in Figure I-4-1.

International scope

4.8 The emerging and future ATM system design must meet the test of international acceptance and interoperability. It must allow for implementation at various levels of sophistication to provide services tailored to specific applications and regions. In this context, it is essential to ensure that adjacent systems and procedures are able to interface in such a way that boundaries are transparent to airspace users.

Evolutionary transition process

4.9 The development and implementation of the new ATM system must be evolutionary. It is recognized that it is impractical for this evolution to be completed in time frames of less than several years. Such long transition periods place a heavy burden on users and service providers when the new systems replace in-service systems because the two must be operated side by side during the transition period. Long transitions also amplify the problem of aircraft having to operate in a mixed environment where aircraft have differing levels of CNS/ATM capability. Similarly, there will be a need for an exchange of information between ATM service providers with differing levels of information technology. Furthermore, aircraft operators that have taken a decision to invest at an early stage should achieve some corresponding and appropriate benefits.

4.10 While change in the ATM system will be evolutionary, the operational concept, ATM system architecture, and ATM system design and implementation must provide a well-understood, manageable and cost-effective sequence of improvements that keeps pace with users' needs and culminates in a system meeting the ATM partners' expectations.

* Emerging concept or technology — consensus still to be reached.

Outline of the future ATM system

4.11 The ATM system must accommodate a broad community of users and various levels of avionics equipage. A major design challenge in the development of ATM procedures and techniques, using new technologies to realize system improvements, centres on the roles of the human operators. Information provided to the pilot and air traffic controller and the tasks assigned must be consistent with their management and control responsibilities as well as the innate characteristics and capabilities of human beings. As basic understanding of human factors improves and facilities for testing the human factors aspects of system designs become available, the design process will become easier.

Benefits of global ATM

4.12 A large number of technologically related opportunities and benefits are now available for implementing a worldwide ATM system that will improve ATM services to better meet user requirements. The new technologies and associated ATM procedures will also provide for an improvement in controller productivity and overall enhancement of the work environment. A summary of the benefits expected from new ATM systems is depicted in Figure I-4-2.

NEED FOR AN ATM OPERATIONAL CONCEPT

4.13 Attaining the goal of an integrated, global ATM system requires harmonization and standardization of regional and national system elements and procedures. ICAO is developing new SARPs as part of its work on global ATM. States and industry will then use this material as a guide toward the development and implementation of ATM systems leading toward global harmonization.

4.14 The basis for developing the Standards necessary for harmonization and integration is an ATM operational concept for the emerging and future ATM system which is under development by the Air Navigation Commission with the assistance of the Air Traffic Management Operational Concept Panel (ATMCP) established by the Commission for this purpose. The ATM concept will clarify the expectations and benefits of these ATM systems and give States and industry clear guidance for designing and implementing them. Work on the ATM concept is aimed at obtaining consensus on several issues (i.e. separation assurance*, situational awareness*, etc.).

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* Emerging concept or technology — consensus still to be reached.

Goals of a global system

- To provide greater flexibility and efficiency by accommodating user-preferred flight profiles.
- To improve the existing level of safety.
- To accommodate the full range of aircraft types and airborne capabilities.
- To improve the provision of information to users, including weather conditions, the traffic situation, and the availability of facilities.
- To organize airspace in accordance with ATM provisions and procedures.
- To increase user involvement in ATM decision-making, including air-ground computer dialogue for flight plan negotiation.
- To create, to the maximum extent possible, a single continuum of airspace where boundaries are transparent to users.
- To increase capacity to meet future air traffic demand.

Figure I-4-1. Goals of a global ATM system

4.15 The ATM operational concept will complement the Global Plan and should guide the ATM partners, PIRGs and States in further development of ATM systems. As part of the overall CNS/ATM systems planning process, it will be necessary to consider how the elements of the operational concept could be applied in a particular airspace. In this light, the complete ATM operational concept will consist of the concept developed, taking into consideration the outcome of the step-by-step planning methodology and the operational analysis described in Chapter 3 of the Global Plan. The Air Navigation Commission, with the assistance of the ATMCP, will propose amendments to relevant parts of the Global Plan as appropriate; however, it should be noted that the ATM Operational Concept by Phase of Flight beginning at 4.25 was developed by the ICAO Secretariat prior to the establishment of the ATMCP.

4.16 For the purposes of its development work and for this Global Plan, the ATMCP has delineated an operational concept as:

a) a high-level description of the set of ATM services necessary to accommodate traffic at a given time horizon;

b) a description of the anticipated level of performance required from, and the interaction between, the ATM services, as well as the objects they affect; and

c) a description of the information to be provided within the ATM system and how that information is used for operational purposes.

4.17 In brief, the operational concept describes how the ATM system will operate and identifies the services that will be required. Identification of the specific technologies to be implemented in delivering these services is defined by an "architecture", which itself should form part of a broader ATM implementation plan. ATM implementation plans should be developed by the PIRGs and by States in accordance with Chapter 3 of the Global Plan. Thus, an operational concept drives the architecture. An ATM "concept of use" is a more detailed description of how a particular function or technology could be employed.

4.18 The ATM operational concept being developed will be reached progressively through a series of discrete changes from the current situation. The year 2025 was

Benefits of a global ATM system

- The new ATM capabilities and more accurate data will make it possible to enhance safety, reduce delays, and increase airspace and airport capacity.
- Future ATM operations will become much more flexible, resulting in a greater capability to accommodate user-preferred trajectories. New capabilities will make it possible to permit flexible routing, as well as dynamic modifications to aircraft routes in response to changes in weather and traffic conditions.
- Improved flow management will prevent excessive levels of congestion.
- Data links will transmit a variety of information from appropriately equipped aircraft to the ground and between ground units and provide enhanced information to the cockpit. It will dramatically reduce workload, and reduce the channel congestion and communications errors that characterize the current voice environment.
- Terminal and en-route ATM functions will be integrated to provide smooth traffic flows into and out of terminal areas.
- Air traffic controllers will be able to establish more efficient approach streams.
- The implementation of the global ATM system will provide an effective means of reducing fuel burn and avoid unnecessary aircraft engine emissions, which will help to minimize civil aviation's environmental impact.

Figure I-4-2. Benefits of a global ATM system

selected as the target date for meeting the majority of expectations described in the global ATM operational concept. Descriptions of intermediate stages will be presented using scenarios that combine elements of the current global situations and target concepts.

4.19 With these descriptions as a basis, a vision of the operational concept has taken shape. The goal is to achieve a global ATM system for all users during all phases of flight that meets agreed-to levels of safety and provides for optimum economic operations. In addition, the system envisaged would be environmentally sustainable and would meet national security requirements.

4.20 The global ATM operational concept encompasses two main time periods. The first period, up to 2015, allows for the development of scenarios based on the more realistic assumptions concerning applicability and technological capabilities, and accommodates early implementation steps. The second, from 2015 to 2025, addresses scenarios which incorporate the more visionary options for air traffic management.

Required total system performance (RTSP)*

4.21 ICAO has developed worldwide Standards for many aspects of civil aviation; however, the current ATS system has evolved without globally agreed-to criteria for safety, regularity and efficiency of international civil aviation having been established. A target level of safety has been defined only for some airspaces, but not on a global level. In the absence of agreed-to criteria for airspace/airport capacity and for flexible use of airspace*, there is no common basis for regularity and efficiency worldwide. As a result, there is no assurance that the future traffic demand and airspace users' needs can be met.

4.22 In light of the above, the future system must be viewed in its totality. The total system can be seen as the totality of airspace, the ATM-related aspects of flight operations, and the facilities and services provided.

4.23 RTSP* will specify criteria that should be met by the entire ATM system. RTSP* will allow the ATM providers and users of a given airspace to determine the optimum usage level of an airspace. For example, lower performance standards could be acceptable in a particular airspace, for some or all system elements, if the users were prepared to accept larger separation standards.

4.24 The RTSP* will offer guidance to the ICAO PIRGs and States that carry out the actual planning of the infrastructure that serves international civil aviation.

ATM OPERATIONAL CONCEPT BY PHASE OF FLIGHT

Airport operations

4.25 Increased airport capacity is a major objective of the future ATM system. The design of the future ATM system will contribute to this goal by implementation of techniques, procedures and technologies that fully utilize scarce capacity resources, allowing a higher throughput of traffic and maximizing both approach and departure operating efficiencies. Sophisticated automation and an air-ground digital data link will be required to make maximum use of capacity and to meet throughput requirements by improving the identification and predicted movement of all vehicles on the airport movement area, to include conflict advisories. Additionally, increasing levels of collaboration and information-sharing between users and ATM providers will create a more realistic picture of airport departure and arrival demand, allowing users to make scheduling and flight planning decisions.

4.26 Advanced surface movement guidance and control systems (A-SMGCS) will be used for routing, guidance, surveillance and control of aircraft and vehicles in order to maintain acceptable movement rates under all weather conditions, while improving the required level of safety. A-SMGCS* will also help to ensure that departing aircraft arrive at the holding point of their assigned runway in time to meet departure times required for ATFM.

4.27 A-SMGCS* will give ATM providers an enhanced surveillance capability of the aerodrome surface and will assist in taxi route planning and conflict detection/resolution. Surface movement management will become automated with aircraft/vehicle positional information being derived from on-board systems such as automatic dependent surveillance — broadcast (ADS-B)*. Cockpit and vehicle situational displays will be updated by enhanced surveillance techniques and provide pilots and vehicle drivers with more precise ground manoeuvring guidance in low visibility and/or high traffic density conditions.

Terminal and en-route operations

4.28 Independent IFR approaches to parallel runways spaced as closely as 760 m (2 500 ft) or less might be routinely based on high-data-rate-SSRs and other surveillance techniques (e.g. ADS-B*) and on improved monitor

* Emerging concept or technology — consensus still to be reached.

controller displays and cockpit display of traffic information (CDTI) to the flight crew. This will provide capacity increases in instrument meteorological conditions (IMC) at locations with such runway configuration. In addition, many communities may take advantage of this new capability by constructing closely spaced parallel runways that conserve land.

4.29 Improved metering, sequencing and spacing of arrival traffic using automated metering devices*, will increase runway capacities in IMC to a level approaching present runway capacities in visual meteorological conditions (VMC). Automation tools will assist air traffic managers in establishing efficient flows of approaching aircraft for parallel and converging runway configurations.

4.30 The flow management process will monitor capacity resources and demand at airports and in terminal and en-route airspace. It will implement flow management strategies, where required, to assure that excessive levels of congestion do not develop. The tactical management process will monitor aircraft movements to assure conformance with flight plans and to identify and resolve problems such as imminent separation violations and aircraft incursions into special use airspace. Clearances involving position and time and the ATM data link interface with flight management computers will be principal tools in assuring that ATM constraints are met with minimum deviation from user-preferred trajectories.

4.31 An increased ability to accommodate user-preferred flight profiles and schedules will be gained through improved decision support tools for conflict detection and resolution and for flow management. Terminal and en-route ATM functions will be integrated to provide a system in which traffic flows smoothly into and out of terminal areas.

4.32 Automated and seamless coordination supported by ATS inter-facility data communications (AIDC) will present a transparent system to users. In addition, the data link will also be used to transmit weather observations from appropriately equipped aircraft and to provide a variety of aviation information to the cockpit including weather information and information on the status of facilities and airports. Departure and arrival route structures will be expanded to permit greater use of RNAV departure and arrival routes based on RNP requirements.

Oceanic operations

4.33 Oceanic operations provide a full breadth of opportunity to benefit from new technologies, allowing these operations to experience significant improvements. The overall goal is to make oceanic ATM operations as flexible as reasonably possible in accommodating users' preferred trajectories.

4.34 Future oceanic ATM operations will make extensive use of ADS, HF and satellite-based digital communications, GNSS, aviation weather system improvements and collaborative decision-making. These new capabilities will permit flexible routing and dynamic modifications to aircraft routes in response to changes in weather and traffic conditions.

4.35 Reduced vertical separation minimum (RVSM) above FL 290 has been proven to increase capacity. Furthermore, RNAV, based on established RNP values and achieved using appropriate technology (e.g. GNSS on long oceanic flights), will allow increased capacity through reduced separation minima in the longitudinal and lateral axes. More precise monitoring of aircraft, including various conformance monitoring techniques, will allow separation assurance* to be accomplished with the aid of decision support systems and visual display systems.

Aircraft position and manoeuvre intent

4.36 The best use of airspace and airport capacity requires an efficient airspace structure, which permits collaborative planning between the aircraft and the ground ATM system. The airspace structure should be capable of dynamically adapting to changing circumstances and also accommodating the capabilities and desires of the airspace users, utilizing all available data. As in the past, the quality of the process depends on the timeliness and quality of the position and intent information available to the system and the pilot. Accurate surveillance information will also increasingly be required on the airport surface to support the on-airport movement control process.

4.37 Alternative sources of position data, such as automatic transmission of aircraft-derived position data, will be used in certain areas. SSR, however, will most likely be the standard for high-density traffic terminal area operations, with an increasing use of ADS-B* as a possible complement to SSR. Automated ATS ground systems will use ADS position reports and other data to provide automated flight following and cleared flight plan conformance monitoring. Furthermore, appropriately equipped aircraft will be capable of self-monitoring and automatic reporting of significant

* Emerging concept or technology — consensus still to be reached.

flight variances. This conformance monitoring capability permits verification by the ground system, that the flight is proceeding in accordance with its ATC clearance.

ATM automation

4.38 Automation is seen as one of many resources available to the human operators — controllers and pilots alike — who retain the responsibility for management and direction of the overall ATM system. Additionally, unexpected or unplanned events must be a required part of planning and design when considering the systems that would replace the cognitive and adaptive capabilities of controllers or pilots.

4.39 The air traffic controller's job consists of complex tasks demanding a high degree of skill and active application of unique cognitive abilities such as spatial perception, information processing, reasoning and decision-making. The controller must know where all of the aircraft under his/her responsibility are, and determine how and when to take action to ensure that they remain separated from each other, while also seeing to their requests and needs for descent, climb, take-off, departure, etc.

4.40 Although it is well accepted that the human controller in the system has performed these tasks more than adequately over the years, it is also accepted that improvements could be made by using decision support software tools. These tools are expected to assist the controller to some degree with conflict prediction, detection, advisory and resolution.

4.41 The expectation is that greater degrees of accuracy could be achieved through the sophisticated data processing associated with automation. Furthermore, conflict prediction and detection, based on advanced computational methods, should allow more direct routings. These systems will be introduced in an evolutionary manner as the need arises.

4.42 There are several issues that need to be carefully addressed when considering automation of this nature. The most critical is based on the fact that aircraft do not always do what they are expected to do. The human controller is very flexible and adaptive and quite capable of compensating and/or developing alternative plans. Based on this, it is reasonable that computers and the associated software will assist controllers in accomplishing, initially, a part of their cognitive tasks. It is unrealistic to determine at this early stage, that computers could effectively replace controllers in the near term, mainly because of their uniqueness in providing the aviation system a degree of flexibility.

Global ATM scenarios

4.43 Tables I-4-1 to I-4-5 depict the relationship between ATM and CNS technologies and the benefits expected to be derived. These tables illustrate current common airspace types and are intended to indicate the types of improvements that could be implemented.

4.44 The airspace types are:

— oceanic/continental en-route airspace with low-density traffic;

— oceanic airspace with high-density traffic;

— continental airspace with high-density traffic;

— terminal area with high-density traffic;

— terminal area with low-density traffic.

4.45 These tables should be considered as presenting possible scenarios rather than defining specific requirements. Furthermore, as global ATM planning is increasingly being based on homogeneous ATM areas and major traffic flows, these tables will be updated accordingly.

SAFETY ASSESSMENT AND MONITORING

4.46 Because separation standards have significant impact on the capacity and functioning of an integrated ATM system, it is necessary to develop comprehensive, reliable methods for determining separation standards applicable to new technologies and procedures.

4.47 The ATM operational concept is based on the requirements that planning of ATM systems should ensure ATM system enhancements (e.g. implementing new technology to enable reductions in separation minima) are applied on a subregional basis in accordance with relevant ICAO SARPs, while meeting the requirements of regional air navigation agreements. With regard to the specific issue of reduction in an applied separation minima, they should be selected from those found in the ICAO *Procedures for Air Navigation Services — Air Traffic Management* (PANS-ATM, Doc 4444) and the *Regional Supplementary Procedures* (Doc 7030). These documents should also be revised to meet changing requirements, based on technological and procedural opportunities.

4.48 A prerequisite to the implementation of any reduction in separation minima is the maintenance of a level of safety equal to or better than the present. This safety

Table I-4-1. ATM — oceanic/continental airspace with low-density traffic

Functions	Technical elements		Procedural aspects		ATM benefits
	Ground	Air	Structure	Procedures	
COM					
• AMSS voice and data • HF voice and data	• ATN connectivity to AMSS, HF • ATN end-systems human-machine interface (HMI) • Voice AMSS, HF	• ATN connectivity to AMSS and HF avionics • Voice AMSS, HF	• RCP*	• Data link handling procedures • Message format	• Improved tactical control • Improved pilot/ controller communications • Facilitate ATC/FMS dialogue
NAV					
• GNSS	• NIL	• GNSS receiver • FMS	• RNP • Airspace organization • RNP certification/ approval	• Navigation procedures	• Improved airspace utilization
SUR					
• ADS • ADS-B*	• ATN connectivity to AMSS and HF • Situation display for ADS and ADS-B*	• ATN connectivity with ADS and ADS-B* function and situation display • ADS, ADS-B* avionics	• Airspace organization • RSP*	• Surveillance procedures • Message format	• Reduction of radiotelephony (R/T) workload • Improved situational awareness*
AUTOMATION					
• Decision support systems	• Automated flight data processing • Conflict alert, advisory, prediction and resolution software	• FMS	• Airspace organization	• Automation procedures and algorithm development • Message format	• Increase in direct routings • Improved conflict prediction and resolution

* Emerging concept or technology — consensus still to be reached.

Table I-4-2. ATM — oceanic/airspace with high-density traffic

Functions	Technical elements		Procedural aspects		ATM benefits
	Ground	Air	Structure	Procedures	
COM					
• AMSS voice and data • HF voice and data • Extended VHF voice and data	• ATN connectivity to AMSS, HF, extended VHF • ATN end-systems (HMI) • Voice AMSS, HF, extended VHF	• ATN connectivity to AMSS, HF, extended VHF avionics • Voice AMSS, HF, extended VHF	• RCP*	• Separation criteria • Data link handling procedures • Message format	• Improved tactical control • Improved pilot/controller communications • Facilitate ATC/FMS dialogue
NAV					
• GNSS		• GNSS receiver • FMS	• RNP • Airspace organization including separation criteria • RNP certification/ approval	• Navigation procedures	• Increase airspace capacity by reduction in separation minima due to increased positional accuracy • Improved airspace utilization
SUR					
• ADS • ADS-B*	• ATN connectivity to AMSS, HF and extended VHF • Situation display for ADS and ADS-B*	• ATN connectivity with ADS and ADS-B* function and situation display • ADS and ADS-B* avionics	• Airspace organization including separation criteria • RSP*	• Surveillance procedures • Message format	• Increased airspace capacity by reduction in separation minima due to improved conformance monitoring • Improved airspace utilization • Reduction of R/T workload • Improved situational awareness*
AUTOMATION					
• Decision support systems	• Automated flight data processing • Conflict alert, advisory, prediction and resolution software	• FMS	• Airspace organization	• Automation procedures and algorithm development • Message format	• Increase in direct routings • Increase in user-preferred flight profiles • Increased capacity • Improved traffic planning • Improved conflict prediction and resolution • Improved trajectory planning

* Emerging concept or technology — consensus still to be reached.

Table I-4-3. ATM — continental airspace with high-density traffic

Functions	Technical elements		Procedural aspects		ATM benefits
	Ground	Air	Structure	Procedures	
COM					
• AMSS voice and data • VHF voice and data • SSR Mode S data link	• ATN connectivity to SSR Mode S and VHF • ATN end-systems (HMI) • Voice VHF	• ATN connectivity to VHF and SSR Mode S avionics • Voice VHF	• RCP*	• Separation criteria • Data link handling • Message format	• Improved pilot/controller communications • Facilitate ATC/FMS dialogue • Complement VHF coverage • Reduction of R/T workload
NAV					
• GNSS	• Augmentation	• GNSS receiver • FMS	• Application of RNP • Airspace organization including separation criteria • RNP certification/ approval	• Navigation procedures	• Increased airspace capacity by reduction in separation minima due to increased positional accuracy • Improved airspace utilization
SUR					
• ADS • ADS-B* • SSR	• ATN connectivity to VHF, SSR Mode S • Situation display for ADS and ADS-B*	• ATN connectivity with ADS and ADS-B* function and situation display • SSR Mode S transponder • ADS and ADS-B* avionics	• Airspace organization including separation criteria • Application of RSP*	• Surveillance procedures	• Increased airspace capacity by reduction in separation minima due to improved conformance monitoring • Improved airspace utilization • Reduction of R/T workload • Improved situational awareness* • (ADS, ADS-B*) complement to and possible back-up for SSR • Reduced need for primary surveillance radar (PSR)
AUTOMATION					
• Decision support systems	• Automated flight data processing • Conflict alert, advisory, prediction and resolution software	• FMS	• Airspace organization	• Automation procedures and algorithm development • Message format	• Improved traffic planning • Improved conflict prediction and resolution • Improved trajectory planning • Increase in direct routings • Increase in user-preferred flight profiles

* Emerging concept or technology — consensus still to be reached.

Table I-4-4. ATM — terminal areas with high-density traffic

Functions	Technical elements		Procedural aspects		ATM benefits
	Ground	Air	Structure	Procedures	
COM					
• VHF voice and data • SSR Mode S data link	• ATN connectivity to VHF and SSR Mode S • ATN end-systems (HMI) • Voice VHF	• ATN connectivity to VHF, SSR Mode S avionics • Voice VHF	• Airspace organization • Application of RCP*	• Separation criteria • Message format • Data link procedures	• Improved pilot/controller communications • Facilitate ATC/FMS dialogue • Complement VHF coverage • Reduction of R/T workload
NAV					
• GNSS • ILS • MLS	• ILS • MLS • Augmentation systems	• GNSS receiver • ILS • MLS • MMR • FMS	• Application of RNP • Airspace organization including separation criteria • RNP certification/ approval	• Approach procedures	• Increased airspace capacity by reduction in separation minima due to increased positional accuracy • Improved airspace utilization
SUR					
• ADS • ADS-B* • SSR	• ATN connectivity to VHF and SSR Mode S • Situation display for ADS and ADS-B*	• ATN connectivity with ADS and ADS-B* function and situation display • SSR Mode S transponder • ADS and ADS-B* avionics	• Airspace organization including separation criteria • Application of RSP*	• Surveillance procedures development	• Increased airspace capacity by reduction in separation minima due to improved conformance monitoring • Improved airspace utilization • Reduction of R/T workload • Improved situational awareness* • (ADS, ADS-B*) complement to and possible back-up for SSR • Reduced need for PSR
AUTOMATION					
• Decision support systems	• Automated flight data processing • Conflict alert, advisory, prediction and resolution software • Metering software	• FMS	• Airspace organization	• Automation procedures and algorithm development • Message format	• Increase in direct routings • Improved sequencing and flight profiles • Improved trajectory planning • Improved traffic planning • Improved conflict prediction and resolution

* Emerging concept or technology — consensus still to be reached.

Table I-4-5. ATM — terminal areas with low-density traffic

Functions	Technical elements		Procedural aspects		ATM benefits
	Ground	Air	Structure	Procedures	
COM					
• VHF voice and data	• ATN connectivity for VHF • ATN end-systems • Voice VHF	• ATN connectivity to VHF avionics • Voice VHF	• RCP*	• Data link procedures • Message format	• Improved pilot/controller communications • Facilitate ATC/FMS dialogue • Complement VHF coverage
NAV					
• GNSS	• Augmentation systems	• GNSS receiver	• RNP certification approval	• Approach procedures	• Improved airspace utilization
SUR					
• ADS • ADS-B* • SSR	• ATN connectivity for VHF • Situation display for ADS and ADS-B*	• ATN connectivity with ADS and ADS-B* function and situation display • ADS, ADS-B* avionics	• RSP*	• Surveillance procedures	• Improved airspace utilization • Improved situational awareness* • Reduced need for PSR
AUTOMATION					
• Decision support systems	• Situation display • Automated flight data processing	• FMS		• Automation procedures and algorithm development • Message format	• Increase in user-preferred flight profiles • Improved traffic planning • Improved conflict prediction and resolution

* Emerging concept or technology — consensus still to be reached.

requirement must be taken into account in the development of automated systems. Such systems should, to the extent possible, be flexible with regard to separation minima parameters. For example, a separation minimum of 7 minutes in oceanic airspace may not meet the target level of safety at a given point in time whereas 8 minutes may. Furthermore, flexibility must also be considered in the context of the progression of planned reductions in separation minima.

4.49 Once the need to enhance operational efficiency in a particular area has been identified, the potential benefits to be gained, the costs to the user community and the impact on air traffic operations must be investigated. Part of this analysis will establish the capabilities necessary in the ATM system, given the performance and capabilities of the existing aircraft population, leading to an agreed safety level for the operations desired. Within the context of the agreed safety measure, a thorough analysis of operational safety, including consideration of contingencies and environmental conditions, should be conducted to establish the aircraft requirements and to validate the ground system requirements. Once these requirements are understood, the need for rule-making and a cost-benefit analysis must be determined. Any operational procedures necessary to support the safety constraints and contingencies or regulatory changes must be identified and coordinated with the user community.

4.50 Planning and preparation for the changes should be initiated using the results of a requirements assessment. The effort can be divided into a number of activities, which would be initiated by the development and coordination of any necessary amendments to regional supplementary procedures which would contain criteria to implement operational enhancements and/or reduced separation minima. The result will lead to efforts to establish the State approval process for aircraft and operators as well as a means for investigating and tracking significant operational errors and incidents.

4.51 A safety case will be completed whenever necessary. There will also be a need to establish an ongoing process to assess operational safety once the change takes effect. A verification trial plan that will determine the technical and operational data necessary to gain confidence that the requirements and methods to implement new Standards are effective should be conducted in parallel with updates of documentation.

4.52 With the analysis and planning complete, it will be possible to begin operational implementation. During the operational phase of implementation, it will be necessary to ensure that appropriate organizations and States initiate ongoing safety and performance monitoring programmes and improvement processes. This analysis will involve tracking errors, reviewing incidents that affect operational safety and taking steps to mitigate against reoccurrence, and assessing feedback from the user community on the safe and effective use of operational procedures. The feedback process may generate further initiatives.

GLOBAL ATM IMPLEMENTATION

4.53 The future ATM system must clearly be compatible with ATM developments worldwide. It must be possible to equip aircraft with a minimum set of avionics 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. In oceanic areas, 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.

4.54 The ATM operational concept should assist and guide airspace planners in airspace and systems design, with the goal of providing for the safe and efficient operations of aircraft for each of the phases of flight. This includes navigation along the intended route of flight, clearance from obstacles, support of separation minima and added autonomy of flight*. The main interdependent elements that affect the achievement of predetermined levels of safety, efficiency and regularity are:

— nature of traffic;

— frequency of occurrence of potential conflict situations;

— separation minima;

— controller's intervention capability;

— communications performance;

— aircraft navigation performance; and

— surveillance performance.

* Emerging concept or technology — consensus still to be reached.

4.55 After determining the ATM requirements of a given area, a strategy should be developed to guide the implementation of the CNS/ATM systems infrastructure, taking into account the performance capabilities of the CNS elements and the ATM objectives. These performance capabilities are used to determine airspace design (e.g. separation minima, route spacing, sectorization, instrument procedures required and the capability for intervention by the ground-based ATM service provider when required).

4.56 It is well understood that not everything that is possible is also necessary and that a balance must therefore be reached between the requirements first put forward for the improvement of services and the cost involved in implementation. An increase or decrease in the requirements for any single parameter or element may allow a corresponding increase or decrease in some or all of the other parameters. Seen from this light, technology is not an end in itself.

4.57 When fully developed, the operational concept will clarify the benefits of global ATM and will give ICAO regional planning and implementation groups, States and industry a clear objective for designing and implementing ATM systems.

4.58 The process of planning for the implementation of CNS/ATM systems should begin with the step-by-step approach outlined in Part I, Chapter 3, in full consideration of the guidance provided in this and other chapters of the Global Plan, as well as of the SARPs so far developed and other guidance material identified. Seen in this light, the Global Plan itself forms the basis for the ATM operational concept and can, in fact, be seen as part of that concept. The planning work should be integrated with the substantial work already accomplished by the planning and implementation regional groups. The Global Plan and the evolving notion of the global ATM system requires an evolutionary and flexible approach to planning and implementation.

GENERAL TRANSITION ISSUES

4.59 The transition from today's ATM structure to one of collaborative air traffic management enabled by the global ATM system should be carefully planned to avoid degradation in system performance. The level of safety attainable today will need to be assured throughout the transition. Careful planning will also be necessary to ensure that aircraft are not unnecessarily burdened by the need to carry a multiplicity of existing and new CNS equipment during a long transition cycle.

4.60 For reasons of both economy and efficiency, it is necessary to ensure that differences in the pace of development around the world do not lead to incompatibility among elements of the overall system. In particular, given the wide coverage of satellite systems, worldwide coordination is necessary.

4.61 It is recognized that there are major long-term consequences of adopting new systems that will eventually permit the elimination of a variety of current systems. Decisions on whether particular systems can be removed will depend on many factors. One essential factor is the demonstrated capability of a new system. Moreover, a clear and compelling case for transition to the global ATM system must include consideration of the benefits perceived by the aviation community.

4.62 Guidelines for transition to the future systems encourage equipage by users for the earliest possible accrual of systems benefits. Although a transition period of dual equipage, both airborne and ground, is often necessary to ensure the reliability and availability of a new system, the guidelines are aimed at minimizing this period to the extent practicable. Appendix B to this chapter lists the guidelines that States, regions, users, service providers and manufacturers should consider when developing CNS/ATM systems or planning for implementation of such systems.

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APPENDIX A TO CHAPTER 4

ATM OPERATIONAL REQUIREMENTS IN AN RNP/RNAV ENVIRONMENT

Code	ATM operational enhancements*	Required functions — air	Required services — ground	Notes
AIR TRAFFIC SERVICES				
1. Routings and required conventional functionalities				
1A	• fixed routes	• RNAV capability	• NAVAID infrastructure	
1B	• flexible routes	• RNAV capability	• NAVAID infrastructure	
2. Routings and required CNS/ATM functionalities				
2A	• fixed routes	• DCPC (voice/data) • RNP/X approval/certification • FMS	• DCPC (voice/data)	• see Notes 1, 2 and 3
2B	• flexible routes	• DCPC (voice/data) • RNP/X approval/certification • FMS	• DCPC (voice/data)	• see Notes 1, 2 and 3
2C	• dynamic user-preferred re-route (e.g. DARPs)	• DCPC (voice/data) • RNP/X approval/certification • Aeronautical operational control (AOC) data link • Direct flight plan uploads • FMS	• DCPC (voice/data) • AOC data link • flight plan generation • AOC/ATS data communications	• utilization dependent on airspace complexity • see Notes 1, 2 and 3
2D	• autonomy of flight** concept	• to be developed	• to be developed	• concept still undergoing definition by ICAO
3. En-route vertical separation reductions				
3A	• 300 m (1 000 ft) vertical separation between FL 290 and FL 410	• RVSM certification/ operational approval • voice/data communications	• height monitoring sampling • voice/data communications	• see ICAO *Regional Supplementary Procedures* (Doc 7030) NAT/RAC • sampling to verify that aircraft population height-keeping accuracy is in conformance with appropriate Standards
4. En-route longitudinal separation reductions				
4A	• 80 NM (non-radar environment)	• RNAV • MNPS approval • voice/data communications	• Mach number technique (MNT) • 60-minute position reporting • voice/data communications	• MNT may be required • MNPS is used in a generic sense and may not be required in all cases • see Note 1
4B	• 50 NM (non-radar environment)	• RNP 10 approval/certification • FMS • DCPC (voice/data)	• 30-minute position reporting • MNT • DCPC/voice/data	• final requirements to be developed • MNT may be required • see Notes 1, 2 and 3
4C	• 30 NM (non-radar environment)	• FMS • DCPC (voice/data) • RNP 4 approval/certification • ADS	• DCPC (voice/data) • ADS	• final requirements to be developed • see Notes 1, 2, 3 and 4
4D	• less than 30 NM (non-radar environment)	• FMS • DCPC (voice/data) • RNP/X approval/certification • ADS	• DCPC (voice/data) • ADS	• final requirements to be developed • see Notes 1, 2, 3 and 4
4E	• 10 minutes (non-radar environment)	• RNAV • voice/data communications	• MNT where prescribed • voice/data communications	• RNAV capability may not be required in all situations • accurate time requirement/ common time reference • see Note 1

Code	ATM operational enhancements*	Required functions — air	Required services — ground	Notes
4F	• 7 minutes (non-radar environment)	• FMS • DCPC (voice/data) • RNP 10 approval/certification	• DCPC (voice/data)	• final requirements to be developed • accurate time requirement/ common time reference • see Notes 1, 2 and 3
5. En-route lateral separation				
5A	• 60 NM (non-radar environment)	• RNP 12.6 approval/certification • voice/data communications	• voice/data communications • pilot position reports	• presently implemented as MNPS and AUSEP in the NAT and Asia Pacific Regions respectively • performance monitoring may be required • see Notes 1, 3 and 5
5B	• 50 NM (non-radar environment)	• RNP 10 approval/certification • voice/data communications	• voice/data communications • pilot position reports	• performance monitoring may be required • see Notes 1, 3 and 5
5C	• 30 NM (non-radar environment)	• RNP 4 approval/certification • DCPC (voice/data)	• DCPC (voice/data)	• final requirements to be developed • performance monitoring may be required • see Notes 1, 2, 3 and 5
5D	• less than 30 NM (non-radar environment)	• DCPC (voice/data) • RNP/X approval/certification • ADS	• DCPC (voice/data) • ADS	• final requirements to be developed • performance monitoring may be required • see Notes 1, 2, 3, 4 and 5
5E	• 16.5 NM (uni-directional) (non-radar environment)	• RNP 5 approval/certification • DCPC voice	• DCPC voice	• relates to VOR reference system • see Notes 3, 5, 6 and 7
5F	• 18 NM (bi-directional) (non-radar environment)	• RNP 5 approval/certification • DCPC voice	• DCPC voice	• relates to VOR reference system • see Notes 3, 5, 6 and 7
5G	• 10 to 15 NM (radar environment)	• RNP 5 approval/certification • DCPC voice	• radar • DCPC voice	• system safety evaluation required • see Notes 3, 5, 6 and 7
5H	• 8 to 12 NM (radar environment)	• RNP 4 approval/certification • DCPC voice	• radar • DCPC voice	• system safety evaluation required • see Notes 3, and 5
AIRSPACE MANAGEMENT				
6A	• airspace integration and flexible use of airspace**	• to be provided to all aircraft	• separate databases for: — aircraft — AOC — military reserved airspace — national security — environmental — aeronautical information — airports — weather — traffic — SAR — rules of the air	• this provides the information that is necessary to create flexible use of airspace**

Code	ATM operational enhancements*	Required functions — air	Required services — ground	Notes
AIR TRAFFIC FLOW MANAGEMENT				
7A	• integrated air traffic flow management	• to be provided to all aircraft	• separate databases for: — aircraft — AOC — airspace requirements — environmental — aeronautical information — airports — weather — traffic forecast • integrated automation of database management • AOC interface • ATC/ASM/ATFM interface	• purpose is to ensure an optimum flow of air traffic by balancing traffic demand and ATC capacity

* For each particular operational enhancement, there will be a need for the airlines and the ATS providers to review existing procedures to identify what new requirements are required prior to operational implementation.
** Emerging concept or technology — consensus still to be reached.

NOTES

1) *When a data link is used for communications, voice communications must be available. Depending upon the separation requirement, the voice requirement may be for direct voice.*

2) *Performance requirements of a data link depend upon the application for which it is being used.*

3) *The approval for RNP operations is specific for each RNP type.*

4) *The ADS requirement is associated with and related to the overall communications performance requirements for position reporting.*

5) *Lateral route systems require regional safety assessments and agreement.*

6) *In some cases, the RNP requirement may be met without the use of RNAV; however, in future CNS/ATM systems, all aircraft are expected to be RNAV-equipped.*

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APPENDIX B TO CHAPTER 4

GUIDELINES FOR TRANSITION TO GLOBAL AIR TRAFFIC MANAGEMENT SYSTEMS

GENERAL

- The ATM system should ensure the provision of safe, uniform procedures on a global basis.

- The ATM system must improve upon the present, agreed-to levels of safety.

- The ATM system should offer users maximum flexibility and efficiency in airspace utilization, taking into account their operational and economic needs, as well as the ground system capabilities.

- The ATM system should facilitate a dynamic airspace environment that allows aircraft operators to follow preferred and flexible flight profiles with minimum constraints.

- The ATM system must be capable of functional compatibility of the data exchanged between the airborne and the ground elements, in order to ensure global efficiency.

- The ATM system should allow for the sharing of airspace between different categories of users, and the airspace should be organized as flexibly as possible, considering different levels of aircraft equipage.

- The various elements for the overall ATM system should be designed to work together effectively to ensure homogeneous, continuous and efficient service to the user from pre-flight to post-flight.

- Pilots and air traffic controllers should be kept involved in the ATC process, and automated systems should be human-centred.

- The ATM system should be capable of working with a wide variety of traffic densities, aircraft types, avionics sophistication, etc.

- The ATM system should not be overly sensitive to random disturbances, such as outages, emergencies and errors in forecasting.

TRANSITION AND IMPLEMENTATION

- The development and implementation of the ATM system should be evolutionary.

- The design of the ATM system should provide a well-understood, manageable, cost-effective sequence of improvements that keeps pace with the users' needs and culminates in a system meeting safety, capacity, efficiency and environmental demands.

- The ATM system design should allow for implementation at various levels of sophistication to provide services tailored to specific applications and regions.

- Future ATM systems should be implemented in a way that allows adjacent systems to interface so that boundaries are transparent to airspace users.

- During the transition period to future ATM systems, present levels of integrity, reliability and availability of existing systems must be maintained.

AIRSPACE ORGANIZATION AND MANAGEMENT

- In the design of the future airspace structure, airspace boundaries and divisions should not prevent the efficient use of automated conflict detection and resolution techniques nor the exploitation of the advanced avionics of modern aircraft.

- The aim of airspace sectorization should be to develop an optimum airspace configuration, in combination with the use of other suitable methods for increasing ATM system capacity.

- Airspace use should be carefully coordinated and monitored in order to cater for the conflicting legitimate requirements of all users and to minimize any constraints on operations.

- When it is unavoidable to segregate different categories of traffic, the size, shape and regulation category of airspace should be tailored to the minimum required to protect the operations concerned.

- The permanent segregation of airspace should be avoided in favour of flexible use of airspace*; however, where it is necessary to cater for specific flight operations, e.g. military, reservation of airspace for such events should be limited in time and space to the minimum required.

- Efficient communications should be provided between the entities providing services to air traffic, in order to enhance civil-military coordination in real-time.

- Consideration should be given to combining flight information services with available surveillance services outside controlled airspace.

- To facilitate airspace design, planning should be based on an area control concept rather than on a fixed-route network whenever practicable/feasible.

- Random RNAV areas should be introduced whenever practicable/feasible in order to enable aircraft to fly their preferred routes.

- Fixed-route systems based on RNAV should only, if necessary, be applied in high-traffic density airspace. Such route systems shall be published and shall be designed to enable air traffic to be separated systematically, while seeking to permit economical flight paths.

- Areas that should strive for the earliest and shortest implementation are those where there are known constraints in today's system; that is, where the users' needs are not met, or where the users' benefits cannot be fully realized.

AIR TRAFFIC SERVICES

- The implementation and application of automation and other advanced technologies, while necessary to increase efficiency and regularity, should maintain and, where possible, improve the controller's work environment.

- The implementation of an improved air navigation system should be supported by improvements in the communications, navigation and surveillance systems and by advanced automation functions.

- Airspace capacity increases should not cause a concurrent increase in controller workload.

- Automation aids such as conflict prediction and resolution advisory functions should be introduced to assist the controller where practicable. The accuracy of these systems must be assured.

- Safety levels must be improved as the use of automation increases.

- Automation aids that improve planning data accuracy and reduce the necessity for controller interventions to resolve conflicting situations must contain provisions which allow for required controller awareness in relation to the traffic situation.

- The ATM system will allow for a transfer of responsibility of some separation functions from ground to airborne systems under specific circumstances. The trend may continue based on advancements in cockpit situational awareness; however, the ground system should remain as the overriding authority in all cases where arbitration is required.

- The data link application should take place during an early stage of the transition phase, based on the availability of any of the foreseen data link systems.

- Application of the data link should aim for a reduction of voice communications load and also for an improvement in the provision of flight data (short-term intent and four-dimensional profile data for the entire flight route) by providing FMS data to the ground ATC system.

- Communications networks between ATM facilities within a State and ATM facilities in adjacent States should be established if they do not already exist.

- States and/or regions should coordinate to ensure that where ATC applications, supported by AMSS such as ADS, are to be introduced, they be introduced simultaneously in adjacent flight information regions (FIRs) through which there are major traffic flows.

- States should develop operational procedures, in collaboration with neighbouring FIRs, for the implementation of new systems such as ADS within airspace under their control, where such an application would be advantageous.

- Rules and procedures should facilitate the operation of aircraft with different equipment in the same ATM environment.

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* Emerging concept or technology — consensus still to be reached.

- States and/or regions may consider segregating traffic according to CNS capability, and granting preferred routes/flight levels to aircraft with improved capabilities.

- States and/or regions should coordinate to ensure that separation standards and procedures for appropriately equipped aircraft are introduced approximately simultaneously in each FIR through which major traffic passes.

- Systems or other provisions must allow the controller to ensure safe separation in the event of system failures.

- Implementation of new functions should maintain or improve existing or basic functions rather than just replace them and should relieve rather than worsen controller functions.

- Rules and procedures should be developed to facilitate the transfer of aircraft between adjacent systems which provide different levels of services.

- Rules and procedures for sharing responsibility between the ground ATC system and the flight management system, in calculating and maintaining flight profiles, should be clearly defined prior to implementation.

- All the future automation specifications for ATC systems should provide for functional coherence between air traffic flow management and air traffic control systems.

AIR TRAFFIC FLOW MANAGEMENT (ATFM)

- Data on likely future demands should be collated from historical information, planned development by airports and airlines, aircraft manufacturers' order books, plus the macro-economic forecasts of trends in the home and other State economies.

- A recognized and common methodology for the assessment of the capacity of the current and planned ATM system should be developed to include sector capacities and, in particular, "choke" points.

- Regions should consider the introduction of a centralized flow management unit.

- Where more than one flow management unit exists, plans to harmonize procedures and practices with adjacent units should be developed.

HUMAN FACTORS

- Planning and implementation of improved ATM capabilities should include consideration of Human Factors impacts and requirements. The goals listed for the future ATM system should be qualified in relation to human factors, at least in terms of the following considerations:

a) the level of safety targeted for the future system should be defined not only with reference to various system statistics, but also with reference to error-inducing mechanisms related to human capabilities and limitations as well as important individual cases;

b) the definition of system and resource capacity should include reference to the responsibilities, capabilities and limitations of ATS personnel and air crews who must retain situational awareness and understanding in order to carry out all of their responsibilities;

c) the dynamic accommodation of three- and four-dimensional flight trajectories to provide user-preferred routings, while an ultimate goal for users, may initially be restricted by human capabilities and the need to organize the flow of air traffic in an orderly manner in order to provide separation. The transition period will need careful research and evaluation of Human Factors aspects;

d) the provision of large volumes of potentially relevant information to users and ATS personnel should be limited to that which is absolutely necessary and be mediated by methods that effectively package and manage such information to prevent information overload, while providing information pertinent to particular operational needs;

e) a single airspace continuum should be free of operational discontinuities and inconsistencies between kinds of airspace and kinds of facilities that affect the responsibilities and activities of air crews or ATS personnel at functional boundaries;

f) the organization of airspace in accordance with ATM procedures should also be readily learned, recalled and, to the maximum practical extent, intuitively understood by air crews and ATS personnel; and

g) responsibilities of pilots, air traffic controllers and system designers should be clearly defined prior to the implementation of new automated systems and tools (e.g. conflict resolution advisories, data link, ADS, etc.).

AERODROME OPERATIONS

- Metering, sequencing, and spacing aids should be introduced in areas where there are frequent delays for aircraft arriving in all weather conditions.

- Simultaneous approaches to closely spaced parallel runways should be implemented at locations where technology and procedures have been developed that permit such use.

- Alternative approach capabilities should be considered for terminal applications where there are closely spaced airports, closely spaced parallel runways, noise footprint requirements, terrain/obstacle clearance requirements, or limited real estate available for new runway construction.

- Data link communications should be considered at airports to relieve air-ground voice communications congestion, and thereby reduce errors or confusion arising from voice communications.

- Automated surface movement guidance and control systems, in conjunction with surface detection radar or differential GNSS equipment, which associate call signs with displayed surface locations and contain controller alerting capabilities, should be provided where the traffic density and/or local conditions warrant this.

- Lighting systems, positional display systems and other devices that assist pilots and controllers in preventing runway incursions should be introduced according to local needs.

Chapter 5

COMMUNICATIONS SYSTEMS

REFERENCES

Annex 10 — *Aeronautical Telecommunications*
Manual on Mode S Specific Services (Doc 9688)
Manual on HF Data Link (Doc 9741)
Handbook on Radio Frequency Spectrum Requirements for Civil Aviation including Statement of Approved ICAO Policies (Doc 9718)
Manual of Technical Provisions for the Aeronautical Telecommunication Network (ATN) (Doc 9705)
Comprehensive Aeronautical Telecommunication Network (ATN) Manual (Doc 9739)
A Planning Guide for the Evolutionary Development of the Data Interchange Portion of the Aeronautical Fixed Service (Circular 261)
Manual of the Secondary Surveillance Radar (SSR) Systems (Doc 9284)

FUNCTION

5.1 The communications element of CNS/ATM systems provides for the exchange of aeronautical data and messages between aeronautical users and/or automated systems. Communications systems are also used in support of specific navigation and surveillance functions.

COMMUNICATIONS SERVICES ENVISAGED

5.2 There are basically two categories of aeronautical communications:

a) safety-related communications requiring high integrity and rapid response:

   1) air traffic services communications (ATSC) carried out among ATS units or between an ATS unit and an aircraft for ATC, flight information, alerting, etc;

   2) AOC communications carried out by aircraft operators on matters related to safety, regularity and efficiency of flights; and

b) non-safety related communications:

   1) aeronautical administrative communications (AAC) carried out by aeronautical personnel and/or organizations on administrative and private matters; and

   2) aeronautical passenger communications (APC).

5.3 In general, communication systems used in CNS/ATM systems are capable of carrying both of the above-mentioned categories. However, safety-related communications shall always have priority over non-safety related ones.

MAIN FEATURES OF NEW COMMUNICATIONS SYSTEMS

5.4 There are some fundamental differences between conventional aeronautical communications systems and those which form part of the new CNS/ATM systems. Some key features of the new systems, which significantly differ from conventional ones, are as follows:

a) most routine communications are done by data interchange;

b) voice communications are mainly used in non-routine and emergency situations; and

c) there is emphasis on global connectivity and operation.

Such features allow for better use of communication channels and enable facilities to be shared among many users.

AIR-GROUND COMMUNICATIONS

5.5 It is envisaged that most routine air-ground communications in the en-route phase of flight will be via digital data interchange. For this purpose, the user often selects a particular message from a pre-constructed set of messages using a screen menu, adds some specific parameters (or free text) and then sends it. Some data transfers take place between automated airborne and ground systems without the need for manual intervention. Such data exchanges will greatly reduce the volume of voice communications and therefore reduce the workload of pilots and controllers. In busy terminal areas, however, the use of voice communications will likely still be preferred. For emergency or non-routine communications, voice will remain as the primary means of air-ground communications.

5.6 Transmission of air-ground messages is carried out over one of the following radio links:

a) AMSS — Geostationary communications satellites, designed specifically for mobile communications, offer wide/near global coverage and both voice and data communications channels. The use of AMSS is particularly suited to aircraft flying in oceanic and/or remote continental airspace;

b) VHF (Analog) — Existing VHF analog radios have excellent operational reliability and will continue to be used for voice communications in busy terminal areas as well as for general non-routine communications in their areas of coverage. Where the saturation of VHF frequency bands for aeronautical communications may occur, provisions have been made to reduce the channel spacing from 25 kHz to 8.33 kHz to increase the number of available channels in that area;

c) HF (Analog) — Radio communications using the HF band for long distance contacts have reliability limitations imposed mainly by the variability of propagation characteristics. It is envisaged that with increased use of AMSS in oceanic/remote areas, congestion on HF channels will be relieved. Until a new satellite constellation suitable for aeronautical use, covering the entire globe, is put in place for flights over polar regions, HF will remain as the only available means of communications in these areas (e.g. polar areas);

d) VDL Mode 2 — This mode provides an air-ground, ATN-compatible, data link and uses digital radio techniques. The nominal data rate of 31.5 kbps is compatible with the 25 kHz channel spacing used in analog VHF radio and for VDL Mode 3 (integrated voice and data). The modulation scheme used in Mode 2 is capable of supporting ATN protocol suites for different operational applications, thereby greatly increasing the efficient use of the VHF channel;

e) VDL Mode 3 — This mode uses a time division multiple access (TDMA) technique and is capable of integrating both voice and data communications systems. The improved utilization of the VHF spectrum is achieved through the provision of four separate radio channels over one carrier (25 kHz channel spacing);

f) VDL Mode 4 — This mode uses a self-organizing time division multiple access (STDMA) technique and is intended to be used for surveillance applications (e.g. ADS and ADS-B). This mode is being considered for use in other air-ground data link applications;

g) SSR Mode S data link — The SSR Mode S data link provides surveillance capability and an air-ground data link, which is specifically suitable for limited data messaging in high-density areas. It is capable of operating in an environment where different levels of Mode S data link capabilities exist; and

h) HF data link — The HF data link provides an air-ground data link which is ATN-compatible and is primarily considered to complement AMSS in oceanic/remote areas.

5.7 AMSS, VDL, SSR Mode S and HF data links use different data transmission techniques, but as individual networks, they all use the same network access protocol in accordance with the International Organization for Standardization (ISO) — Open Systems Interconnection (OSI) reference model. This provides for their interconnection to other ground-based networks so that the aircraft end of any of these data links can be connected to any ground-based system by adopting common interface services and protocols, also based on the ISO OSI reference model. The communications service, which allows ground, air-ground and avionics data subnetworks to interoperate for the specified aeronautical applications, is the ATN. The above-mentioned air-ground data links are ATN-compatible and can therefore constitute ATN subnetworks. In an ATN environment, subnetworks are connected to other subnetworks through ATN routers, which select the "best" route for transmission of each data message. As such, the choice of the air-ground data link is often transparent to the end-user.

5.8 Radio links used for communications with aircraft in flight are of extreme importance to the safety, regularity and economy of flights. As such, the necessary technical and institutional arrangements must be in place to:

a) ensure the availability of a sufficient radio frequency (RF) spectrum for aeronautical services, noting present and foreseen levels of traffic; and

b) prevent RF interference (RFI) into frequencies, bands, services and users of aeronautical radio systems; and

c) allow the provision of communications services by commercial service providers.

GROUND-GROUND COMMUNICATIONS

5.9 It is envisaged that most routine communications between ground-based aeronautical users and systems will be by data interchange. Such interchanges between entities such as meteorology offices, NOTAM offices, aeronautical data banks, ATS units, etc., may be in any of the following forms:

a) free-text messages;

b) pre-selected data messages (with some manually added parts); and

c) automated data interchange between computerized systems.

5.10 A variety of ground networks, implemented by States, a group of States or commercial service providers, will continue to provide data communications services to aeronautical users. However, only networks that use packet switching techniques and are compatible with the ISO OSI reference model will be able to use the internet working services of the ATN. With gradual implementation of the ATN, the use of the aeronautical fixed telecommunication network (AFTN) will diminish. During the transition period, however, interconnection of AFTN terminals to the ATN will be possible via special gateways.

5.11 Voice communications between ATS units will continue to be required for emergency or non-routine cases. Considering the relatively low usage of voice communications, dedicated direct-speech circuits will gradually be replaced with aeronautical switched networks capable of handling both voice and data. There is also a trend to use fully digital voice switching and signalling techniques as more flexible and less costly digital leased lines become widely available.

AERONAUTICAL TELECOMMUNICATION NETWORK (ATN)

5.12 The ATN and its associated application processes have been specifically designed to provide, in a manner transparent to the end-user, a reliable end-to-end communications service over dissimilar networks in support of air traffic services. ATN can also carry other communications service types, such as AOC communications, AAC and APC. Some other features of the ATN:

a) enhance data security;

b) are based on internationally recognized data communications Standards;

c) accommodate differing services (e.g. preferred air-ground subnetwork);

d) allow the integration of public/private networks; and

e) make efficient use of bandwidth, which is a limited resource in air-ground data links.

A diagram of the ATN architecture is given in Figure I-5-1.

FUTURE TRENDS

5.13 As a result of advancing technology, new communications systems offer more, better and cheaper services. The use of such new systems for international civil aviation applications is being investigated. Some future communications systems that have the potential of providing the necessary level of service to the aviation community are:

a) non-geostationary satellite systems (using lower orbits), which cover the entire globe and have less power requirements; and

b) new network technologies providing integrated voice and data service.

5.14 The most important question to be asked when considering a new system is whether it meets existing or emerging operational and user requirements. Other factors to be considered are standardization, certification, harmonious deployment by various users, and cost-benefit considerations.

REQUIRED COMMUNICATION PERFORMANCE (RCP)*

5.15 The emergence of several types of data links for the conduct of air-ground data interchange, as well as for the support of specific navigation, surveillance and other functions, has raised the concern that the air navigation system is becoming too complex. Obviously, it would have been ideal to have a single air-ground communications system capable of handling all communications, navigation and surveillance requirements in all types of airspace and for all phases of flight in a cost-effective manner. However, as no such technological solution has yet been found to meet all operational requirements, the aviation community has to consider all available as well as emerging communications systems, though some may only perform a single function or only serve a limited area.

5.16 The availability of several communications systems does provide a degree of flexibility to planning and implementation in different types of airspace; however, the proliferation of subnetworks will add to the complexity of the operation and administration of the global ATN. For example, if a large continental airspace is already covered by VHF for aeronautical communications, perhaps VDL would be the best choice for an air-ground data link since most of the necessary infrastructure (buildings, towers, power supplies, etc.) would already be in place. Similarly, if an extensive network of SSR Mode S has already been implemented in an area, data link capability could be added with relatively small additional investment.

5.17 Although having the choice between several types of communications systems has some advantages from the implementation point of view, it does make the regional planning for air navigation systems more complex, especially when it comes to making contiguous FIRs harmonious and synchronous from the communications point of view. One solution to this problem is to do away with the specification of individual systems and instead, translate all relevant operational requirements in a certain airspace and scenario into a series of communications performance parameters. The term required communications performance (RCP)* therefore refers to a set of well-quantified communications performance requirements, such as capacity, availability, error rate, and transit delay. Once RCP* has been specified for an operational scenario in a given airspace, any single communications system, or combination of systems meeting the set parameters, can be considered as operationally acceptable.

GENERAL TRANSITION ISSUES

5.18 Guidelines for transition to the future systems encourage equipage by users for the earliest possible accrual of systems benefits. Although a transition period of dual equipage, both airborne and ground, is often necessary to ensure the reliability and availability of a new system, the guidelines are aimed at minimizing this period to the extent practicable. Appendix A to this chapter lists the guidelines that States, regions, users, service providers and manufacturers should consider when developing CNS/ATM systems or planning for implementation of such systems.

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* Emerging concept or technology — consensus still to be reached.

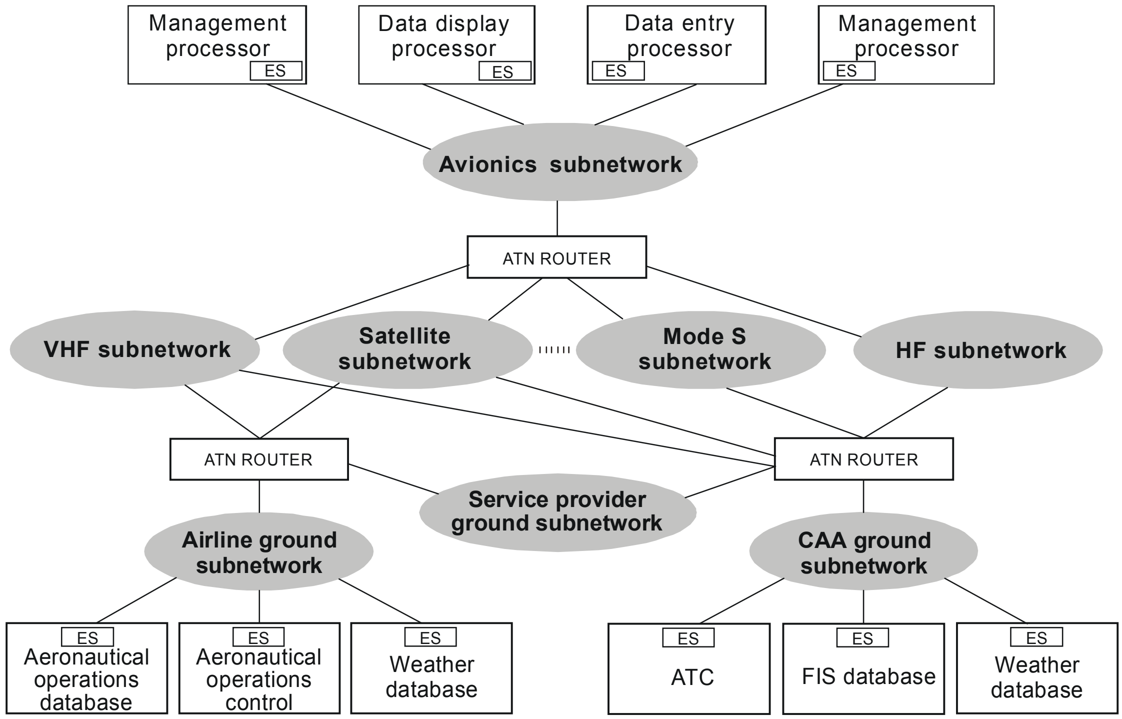

Figure I-5-1. ATN data communications environment

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APPENDIX A TO CHAPTER 5

GUIDELINES FOR TRANSITION TO COMMUNICATIONS SYSTEMS

- States should begin to use data link systems as soon as possible after they become available.
- Transition to AMSS should initially be in oceanic airspace and in continental en-route airspace with low-density traffic.
- States/regions should coordinate to ensure that where ATC applications supported by AMSS are to be introduced, they should be introduced simultaneously in adjacent FIRs through which there are major traffic flows.
- During the transition period after AMSS is introduced, the current levels of integrity, reliability, and availability of existing HF communications systems must be maintained.
- Communications networks between ATC facilities within a State and ATC facilities in adjacent States should be established if they do not already exist.
- The ATN should be implemented in phases.
- If new application message processors and data link systems are implemented, they should support code- and byte-independent data transmission protocols in order to facilitate transition to the ATN.
- States should establish procedures to ensure that both the security and interoperability aspects of the ATN are not compromised.

Chapter 6

NAVIGATION SYSTEMS

REFERENCES

Annex 10 — *Aeronautical Telecommunications*
Guidelines for the Introduction and Operational Use of the Global Navigation Satellite System (GNSS) (Circular 267)
Manual on Required Navigation Performance (RNP) (Doc 9613)
Annex 11 — *Air Traffic Services*

OBJECTIVES

6.1 The navigation element of CNS/ATM systems is meant to provide accurate, reliable and seamless position determination capability, worldwide, through introduction of satellite-based aeronautical navigation.

REQUIRED NAVIGATION PERFORMANCE (RNP)

6.2 Modern aircraft are increasingly equipped with RNAV, the use of which facilitates a flexible route system. Also, by using the concept of RNP, the need for selection between competing systems can be avoided. However, international standardization of navigation techniques, which are in wide use internationally, is still required.

6.3 The RNP concept for en-route operations has been approved by ICAO (Annex 11, Chapter 2) and has been extended to cover approach, landing and departure operations.

6.4 RNP is a statement of navigation performance accuracy within a defined airspace based on the combination of the navigation sensor error, airborne receiver error, display error and flight technical error.

6.5 RNP types for en-route operations are identified by a single accuracy value defined as the minimum navigation performance accuracy required within a specified containment level. The en-route RNP types are described in Doc 9613.

6.6 The RNP types for approach, landing and departure operations are defined in terms of required accuracy, integrity, continuity and availability of navigation. While some RNP types contain accuracy specification of lateral performance only (i.e. similar to en-route), other types also include lateral and vertical performance specifications. The types similar to en-route specification are intended for operations such as non-precision approach or departure. Most RNP types for approach and landing operations do require vertical containment based on navigation system information.

GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS)

6.7 The GNSS is a worldwide position and time determination system, which includes one or more satellite constellations, aircraft receivers, and system integrity monitoring, augmented as necessary to support the RNP for the actual phase of operation.

6.8 The satellite navigation systems in operation are the global positioning system (GPS) of the United States and the global orbiting navigation satellite system (GLONASS) of the Russian Federation. Both systems were offered to ICAO as a means to support the evolutionary development of GNSS. In 1994, the ICAO Council accepted the United States' offer of the GPS, and in 1996 it accepted the Russian Federation's offer of GLONASS.

6.9 The GPS space segment is composed of twenty-four satellites in six orbital planes. The satellites operate near-circular 20 200 km (10 900 NM) orbits at an inclination angle of 55 degrees to the equator, and each satellite completes an orbit in approximately 12 hours.

6.10 The GLONASS space segment consists of twenty-four operational satellites and several spares. GLONASS satellites orbit at an altitude of 19 100 km with an orbital period of 11 hours and 15 minutes. Eight evenly spaced satellites are arranged in each of the three orbital planes, inclined 64.8 degrees and spaced 120 degrees apart.

GNSS AUGMENTATIONS

6.11 To overcome inherent system limitations and to meet the performance requirements (accuracy, integrity, availability and continuity of service) for all phases of flight, GPS and GLONASS require varying degrees of augmentation. Augmentations are classified in three broad categories: aircraft-based, ground-based and satellite-based (see Table I-6-1).

Aircraft-based augmentations

6.12 One type of aircraft-based augmentation (ABAS) is called receiver autonomous integrity monitoring (RAIM), which can be used if there are more than four satellites with suitable geometry in view. With five satellites in view, five independent positions can be computed. If these do not match, it can be deduced that one or more of the satellites are giving incorrect information. If there are six or more satellites in view, more independent positions can be calculated and a receiver may then be able to identify one faulty satellite and exclude it from the position determination calculations.

6.13 Other aircraft-based augmentations can also be implemented and are usually termed aircraft autonomous integrity monitoring (AAIM). An inertial navigation system, for example, can aid GNSS during short periods when the satellite navigation antennas are shadowed by the aircraft during manoeuvres or during periods when insufficient satellites are in view. Augmentation techniques particularly useful for improving availability of the navigation function also include altimetry-aiding, more accurate time sources or some combination of sensor inputs combined through filtering techniques.

Ground-based augmentations

6.14 For ground-based augmentation systems (GBAS), a monitor is located at or near the airport where precision operations are desired. Signals are sent directly to the aircraft in the vicinity (approximately 37 km (20 NM)). These signals provide corrections to increase the position accuracy locally along with satellite integrity information. This capability requires data link(s) between the ground and the aircraft.

Satellite-based augmentations

6.15 It is not practical to provide coverage with ground-based systems for all phases of flight. One way to provide augmentation coverage over large areas is to use satellites to transmit augmentation information. This is known as satellite-based augmentation (SBAS).

6.16 The provision of satellite-based augmentation by geostationary satellites has certain limitations and therefore

Table I-6-1. Examples of GNSS (GPS and GLONASS) augmentation requirements

Operation/phase of flight	RNP type	Generic augmentation architecture		
		Supplemental-means	Primary-means	Sole-means
En-route	RNP 1 and above	ABAS	ABAS*	ABAS* or ABAS + SBAS
Initial or intermediate approach; non-precision approach, departure	RNP 0.3	ABAS	ABAS* or ABAS + SBAS	ABAS* or ABAS + SBAS
Non-precision approach (with vertical guidance)	RNP 0.3/125	ABAS	ABAS* or ABAS + SBAS	ABAS* or ABAS + SBAS
Precision approach down to 60 m (200 ft) (Category I)	RNP 0.02/40	ABAS + SBAS	ABAS + GBAS	ABAS + GBAS

* *Aircraft-based augmentation systems provide limited availability of service. This may lead to operational restrictions based on prediction of one satellite constellation status before departure.*

cannot be expected to support all phases of flight, especially precision approach and landing of higher categories. Since these satellites orbit above the equator, their signals would not be available in polar regions and may be masked by aircraft structure or terrain. This suggests that other GNSS augmentation satellite orbits and/or ground-based augmentation might need to be considered to alleviate these shortcomings.

AVIONICS

6.17 Simple GPS or GLONASS receivers that do not include RAIM capability (or similar forms of integrity monitoring) generally cannot meet the requirements for all phases of flight.

6.18 Multi-sensor systems, using GNSS as one of the sensors, are expected to be in use for the foreseeable future. Such navigation systems generally exhibit better levels of performance than the individual sensor or stand-alone systems. Aircraft using multi-sensor navigation systems, such as integrated GNSS/IRS or GNSS/IRS/FMS, may be certified as meeting levels of RNP which could not be obtained by use of GPS or GLONASS alone.

WGS-84 COORDINATE SYSTEM AND AERONAUTICAL DATABASES

6.19 The successful global implementation of satellite navigation is predicated on the existence of a coordinate and procedures database of a very high quality. Accurate satellite navigation is only possible when the ground-derived coordinates, calculated coordinates, and the satellite system-derived coordinates use the same geodetic reference system.

6.20 In support of evolving satellite-based technology, ICAO adopted WGS-84 as the common geodetic reference datum for civil aviation with an applicability date of 1 January 1998 (Annex 15). Implementation of WGS-84 involves, among other things, the transformation of existing coordinates and reference datums to WGS-84.

6.21 Aeronautical databases are built and updated through the use of surveys of existing navigation aids, position fixes and runway thresholds and through the design of new routes or approach procedures. Systems are to be in place to ensure the quality (accuracy, integrity and resolution) of position data from the time of the survey, to the submission of information to the next intended user. Aeronautical databases must be updated on a regular basis.

EVOLUTIONARY INTRODUCTION

6.22 GNSS implementation will be carried out in an evolutionary manner, allowing gradual system improvements to be introduced. Near-term applications of GNSS are intended to enable the early introduction of satellite-based en-route navigation, using the existing satellite systems (GPS and GLONASS) and primarily aircraft-based augmentations.

6.23 Medium-term applications will make use of existing satellite navigation systems with any augmentation or combination of augmentations required for operation in a particular phase of flight. Longer-term applications will apply to future GNSS.

6.24 Three levels are generally accepted for the introduction of GNSS-based operations:

a) supplemental-means GNSS must meet accuracy and integrity requirements for a given operation or phase of flight; availability and continuity requirements may not be met. Other navigation systems supporting a given operation or phase of flight must be on board;

b) primary-means GNSS must meet accuracy and integrity requirements, but need not meet full availability and continuity of service requirements for a given operation or phase of flight. Safety is achieved by limiting operations to specific time periods and through appropriate procedural restrictions. Other navigation systems can be retained on board to support the primary-means GNSS;

c) sole-means GNSS must allow the aircraft to meet, for a given operation or phase of flight, all four requirements: accuracy, integrity, availability and continuity of service.

SYSTEMS TO SUPPORT APPROACH, LANDING AND DEPARTURE OPERATIONS

6.25 The standard non-visual aids for precision approach and landing are defined in Annex 10, Volume I, Chapter 2. It is intended that the introduction and application of these non-visual aids will be in accordance with the global strategy set forth in Annex 10, Volume I, Attachment B. This strategy will:

a) continue ILS operations to the highest level of service as long as operationally acceptable and economically beneficial;

b) implement MLS where operationally required and economically beneficial;

c) promote the use of multi-mode receivers (MMR) or equivalent airborne capability to maintain aircraft interoperability;

d) validate the use of GNSS, with such augmentations as required, to support approach and departure operations, including Category I operations, and implement GNSS for such operations as appropriate;

e) complete feasibility studies for Category II and III operations, based on GNSS technology, with such augmentations as required. If feasible, implement GNSS for Category II and III operations where operationally acceptable and economically beneficial; and

f) enable each region to develop an implementation strategy for future systems in line with the global strategy.

6.26 The terminology in 6.24 applies to the required state of avionics equipage and the ability of aircraft to meet RNP requirements with, in case of "sole means", no other navigation equipment on board. It is also related to the intended operation (or phase of flight). Operational approvals for aircraft are therefore issued for particular operations and normally identify specific conditions or restrictions to be applied. To this end they may vary from State to State.

6.27 GNSS sole-means approval is therefore a necessary, but not sufficient, condition for termination of present radio navigation services. A number of aircraft may be approved for sole-means GNSS navigation for particular operations or phases of flight. However, the air traffic service provider must provide a navigation service to all users to support all phases of flight. It is therefore necessary to harmonize withdrawal of conventional navaids with the introduction of GNSS navigation service. These considerations are not applicable to airspace where present navaids are not available and GNSS alone can be introduced to benefit GNSS-equipped users.

6.28 When introducing GNSS-based services, each State shall identify the elements of GNSS that are provided (e.g. GPS, GLONASS, SBAS, GBAS) and develop an implementation plan. Where navigation services such as VOR, DME and ILS already exist, States could credit the economic savings associated with the decommissioning of ground-based navigational aids. The cost of implementing SBAS and GBAS should be tied to the provision of user benefits and increased airspace efficiency associated with area navigation and the potential to support lower decision altitude/height to more runways.

6.29 Advantages of GNSS services include the use of GPS/ABAS for en-route and non-precision approach operations where the coverage of ground-based navigation aids does not exist or is limited. In such an environment, GNSS would become the only navigation service as soon as it is introduced. SBAS-based precision approach capability to runways that currently only have a non-precision approach capability will provide further advantages in terms of increased safety and operational efficiency.

6.30 Several technical concerns have been raised with respect to the reliance on GNSS services. Principal among them is the possibility for intentional interference, or jamming, that has the potential to disrupt GNSS navigation services over relatively large areas. States and air navigation service providers should develop plans to reduce the likelihood of such occurrences, to detect and eliminate sources of interference and to ensure that aircraft can continue to operate safely during periods when GNSS signals are disrupted. Depending on the traffic density in a given airspace and the degree of integration and automation of the air navigation system, a safety assessment might demonstrate the need for navigational information derived from different independent sources to address certain threats such as intentional jamming.

6.31 Other risk areas are expected to be mitigated as GNSS continues to evolve to a more comprehensive service, such as the introduction of additional signals for aeronautical use on GPS and GLONASS satellites, augmentation system improvements, and the introduction of additional satellites and satellite systems. Each State will have to evaluate the effectiveness of the mitigation techniques applied in its airspace to determine if it is acceptable to rely on GNSS alone for the provision of navigation service.

GENERAL TRANSITION ISSUES

6.32 Guidelines for transition to the future systems encourage equipage by users for the earliest possible accrual of systems benefits. Provision and carriage of terrestrial and satellite-based navigation equipment are required during the transition period when the reliability and availability of a new system must be proven. Appendix A to this chapter lists the guidelines that States, regions, users, service providers and manufacturers should consider when developing GNSS or when planning for its implementation.

APPENDIX A TO CHAPTER 6

GUIDELINES FOR TRANSITION TO NAVIGATION SYSTEMS

- GNSS should be introduced in an evolutionary manner with increasing benefits commensurate with improvements in navigation service. These benefits should culminate in GNSS sole-means operations.

- The ground infrastructure for current navigation systems must remain available during the transition period.

- States/regions should consider segregating traffic according to navigation capability and granting preferred routes to aircraft with better navigation performance.

- States/regions should coordinate to ensure that separation standards and procedures for appropriately equipped aircraft are introduced approximately simultaneously in each FIR through which major traffic passes.

- In planning the transition to GNSS, the following issues must be considered:

a) schedule for provision and/or adoption of a GNSS service, including aircraft and operator approval processes;

b) extent of existing ground-based radio navigation services;

c) strategy for transition schedule to GNSS capability (i.e. benefits-driven or mandatory);

d) appropriate level of user equipage with GNSS capability;

e) provision of other air traffic services (i.e. surveillance and communications);

f) density of traffic/frequency of operations; and

g) mitigation of risks associated with radio frequency interference.

Chapter 7
SURVEILLANCE SYSTEMS

REFERENCES

Annex 10 — *Aeronautical Telecommunications*
Manual of the Secondary Surveillance Radar (SSR) Systems (Doc 9684)
Manual on Mode S Specific Services (Doc 9688)
Manual on Testing of Radio Navigation Aids, Volume III — Testing of Surveillance Radar Systems (Doc 8071)

CURRENT SURVEILLANCE SYSTEMS

7.1 The surveillance systems presently in use can be divided into two main types: dependent surveillance and independent surveillance. In dependent surveillance systems, the aircraft position is determined on board and then transmitted to ATC. The current voice position reporting is a dependent surveillance system in which the position of the aircraft is determined from on-board navigation equipment and then conveyed by the pilot to ATC by radiotelephony. Independent surveillance is a system that measures aircraft position from the ground. Current surveillance is either based on voice position reporting or based on radar PSR or SSR, which measures range and azimuth of aircraft from the ground station.

FUNCTIONAL DESCRIPTION

Voice position reporting

7.2 Surveillance through voice position reporting is mainly used in oceanic airspace and aerodrome control service or area control service outside radar coverage. Pilots report their position using VHF and/or HF radios.

Primary surveillance radar (PSR)

7.3 The ground-based PSR system provides information on the bearing and distance of the aircraft. PSR does not require carriage of any equipment by aircraft and is capable of detecting almost any moving target. With increasing usage of more advanced surveillance systems, the use of PSR for international air traffic management will diminish. PSR will, however, continue to be used for national applications. Primary radars are currently used for surface movement detection as well as weather detection. Precision approach radars (PARs) are primary radars used for approach operations based on specific procedures for the pilot and the controller; however, use of PARs for civil applications is rapidly decreasing.

Secondary surveillance radar (SSR)

7.4 The SSR interrogates transponder equipment installed in the aircraft. In Mode "A", the aircraft transponder provides identification information, aircraft bearing and distance and in Mode "C", it provides pressure-altitude information. The current SSR is in wide use in many parts of the world where terrestrial line-of-sight surveillance systems are appropriate. The accuracy, resolution and overall performance of range and azimuth information are significantly improved by the application of monopulse (including large vertical aperture antennas) and other advanced processing techniques. The beneficial role of SSR for surveillance purposes can be enhanced through the use of Mode S, which is a technique that uses a unique address (the 24-bit address) for each aircraft. It permits the selective interrogation of Mode S transponder-equipped aircraft and therefore eliminates garbling. It also provides for a two-way data link capability between Mode S ground stations and Mode S transponders. SSR Mode S is the appropriate surveillance tool in high-density traffic areas. The interconnection of ground stations in clusters provides an enhanced surveillance and communications system.

Automatic dependent surveillance (ADS)

7.5 The introduction of air-ground data links, together with sufficiently accurate and reliable aircraft navigation systems, presents the opportunity to provide surveillance services in areas that lack such services in the present infrastructure, in particular, oceanic and other areas where the current systems prove difficult, uneconomic, or even impossible to implement. ADS is an application for use by ATS in which aircraft automatically transmit, via a data link, data derived from on-board navigation systems. As a minimum, the data include the four-dimensional position, but additional data may be provided as appropriate. The ADS data will be used by the automated ATC system to present information to the controller. In addition to providing traffic position information in non-radar areas, ADS will find beneficial applications in other areas, including high-density areas, where ADS may serve as an adjunct and/or back-up for SSR, thereby reducing the need for primary radar. In some circumstances, it may even substitute for secondary radar. As with current surveillance systems, the full benefit of ADS is obtained by supporting complementary two-way pilot/controller data and/or voice communications (voice for at least emergency and non-routine communications).

ADS–broadcast (ADS-B*)

7.6 ADS-B* is an expansion of the ADS technique that involves a broadcast of the position information to multiple aircraft or multiple ATM units. Each ADS-B*-equipped aircraft or ground vehicle periodically broadcasts its position and other relevant data derived from on-board equipment. Any user segment, either airborne or ground-based, within range of this broadcast, can process the information. ADS-B* is currently defined only for line-of-sight operations (e.g. broadcast over VHF digital link or by SSR Mode S extended squitter). ADS-B* is also envisaged to be applied for surface movement, thus being an alternative to surface radar such as airport surface detection equipment (ASDE).

TECHNICAL OPTIONS OVERVIEW

7.7 Implementation of ADS requires:

a) position data supplied by the on-board navigational equipment;

b) message time stamp within 1 second coordinated universal time (UTC);

c) air-ground data link;

d) a ground infrastructure providing the information to ATC; and

e) appropriate air traffic services procedures.

7.8 In the case of ADS, a two-way air-ground data link capability is required, whereas in the case of ADS-B*, one-way data links will suffice because the information is transmitted in a broadcast mode. In addition, synchronized time, such as GNSS time, is highly recommended for the operation of ADS and ADS-B*.

ATM REQUIREMENTS FOR SURVEILLANCE

7.9 ATM requirements for surveillance will vary with the airspace concerned and the traffic density and complexity. The requirements can be defined as follows:

a) current surveillance systems shall provide updated aircraft position reports so as to assure safe separation;

   1) for oceanic and low-density airspace including remote areas, an update rate of 12 seconds is adequate;

   2) in high-density en-route/terminal environments, an update rate of 4 seconds is more appropriate;

b) the accuracy of the surveillance system should support the separation minima for the defined airspace;

c) the surveillance system should enable the ATM to provide the user with a choice of flight path en route and to fully accommodate emergency procedures; and

d) the surveillance system should assist search and rescue operations.

AIRBORNE COLLISION AVOIDANCE SYSTEM (ACAS)

7.10 The airborne collision avoidance system (ACAS) is an aircraft system based on SSR transponder signals, which operates independently of ground-based equipment to provide advice to the pilot on potential conflicting

* Emerging concept or technology — consensus still to be reached.

aircraft that are equipped with SSR transponders (Mode C or Mode S; ACAS cannot detect Mode A only transponders). ACAS I provides information as an aid to "see and avoid" action but does not include the capability for generating resolution advisories (RAs). ACAS II provides vertical resolution advisories (RA) to the pilot. In the case where both encountering aircraft are ACAS-equipped, the manoeuvres can be coordinated automatically (ACAS cross-link). ACAS II is presently being implemented in several States or among groups of States. ACAS II implementation must be considered in association with pressure altitude reporting transponder carriage.

REQUIRED SURVEILLANCE PERFORMANCE (RSP)*

7.11 The emergence of several types of surveillance systems or procedures, in addition to existing surveillance facilities to support ATM functions, has raised concern that the air navigation system is becoming too complex. Admittedly, it would have been ideal to have a single surveillance system capable of meeting the surveillance requirements for all phases of flights in all kinds of airspace. From a cost-effective standpoint, however, surveillance systems with different characteristics and capabilities are required to handle traffic conditions that vary significantly from low-density traffic areas to high-density terminal areas. Until such time as one surveillance system is able to meet all requirements, the aviation community has to consider all options. While the availability of surveillance alternatives provides flexibility during the planning process, it does complicate the harmonization of the surveillance functions. To facilitate the planning, one solution would be to translate all relevant operational requirements into a series of surveillance performance parameters. The term "required surveillance performance (RSP)"* therefore refers to a set of well-quantified surveillance performance requirements such as capacity, availability, accuracy, and update rate. Once RSP* has been specified for an operational scenario in a given airspace, any single system or combination of surveillance systems, meeting the set parameters, can be considered operationally acceptable.

FUTURE TRENDS

7.12 ADS-B* has the potential to complement SSR in terms of coverage (gap filler) and even to replace SSR for low- to medium-traffic density. If aircraft are adequately equipped, the ADS-B* information can also be used as a basis for a cockpit display of traffic information (CDTI)*.

7.13 The level of equipage is expected to increase in accordance with the global mandatory carriage of ACAS and pressure-altitude SSR transponders.

7.14 Airborne separation assurance systems are being developed that may enable the pilot to exercise responsibility in certain circumstances for separation from other aircraft. These systems may provide alert and protection zones around aircraft, together with information to help the pilot monitor and resolve potential conflicts. Other applications are being considered which may include traffic information service-broadcast (TIS-B), ADS-B*, CDTI* and conflict detection and resolution functionality.

7.15 Future surveillance may include an ACAS III* system, which will provide both horizontal and vertical resolution advisories.

GENERAL TRANSITION ISSUES

7.16 Guidelines for transition to the future systems encourage equipage by users for the earliest possible accrual of systems benefits. Although a transition period of dual equipage, both airborne and ground, is often necessary to ensure the reliability and availability of a new system, the guidelines are aimed at minimizing this period to the extent practicable. Appendix A to this chapter lists the guidelines that States, regions, users, service providers and manufacturers should consider when developing CNS/ATM systems or planning for implementation of such systems.

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* Emerging concept or technology — consensus still to be reached.

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APPENDIX A TO CHAPTER 7

GUIDELINES FOR TRANSITION TO SURVEILLANCE SYSTEMS

- States should, as necessary, develop operational procedures in accordance with ICAO SARPs, procedures and guidelines, for the implementation of ADS within airspace under their control.
- Transition to ADS should initially begin in oceanic airspace and in continental en-route airspace with low-density traffic.
- States and/or regions should ensure that ADS is introduced in a coordinated fashion in adjacent FIRs traversed by major traffic flows.
- Where different surveillance methods are employed in adjacent FIRs, commonality or compatibility of the systems should be ensured to enable a service that is transparent to the user.
- During the transition period in which ADS position reporting is introduced, the current levels of integrity, reliability and availability of existing position-reporting systems must be maintained.
- States and/or regions should take action within the ICAO framework to ensure that implementation of changes due to ADS and other systems result in a more efficient use of airspace.
- During the transition to ADS, suitably equipped aircraft should be able to derive benefits from the use of preferred routes without penalizing non-ADS-equipped aircraft.
- ADS should be introduced in incremental phases.
- ADS equipment should be implemented in accordance with Standards and procedures in such a way as to permit the use of ADS as a back-up for other surveillance methods.

Chapter 8

METEOROLOGY

REFERENCES

Annex 3 — *Meteorological Service for International Air Navigation*
Procedures for Air Navigation Services — Air Traffic Management (PANS-ATM, Doc 4444)
Manual of Aeronautical Meteorological Practice (Doc 8896)
Manual of Air Traffic Services Data Link Applications (Doc 9694)

INTRODUCTION

8.1 This chapter describes how the provision of meteorological information supports air traffic management and the technological developments in meteorological systems, which will be required to facilitate the evolutionary transition to new global ATM systems. It also addresses the coordinated national, regional and global planning of meteorological systems needed to realize the potential benefits from improved meteorological information in the new CNS/ATM systems.

METEOROLOGICAL SUPPORT TO INTERNATIONAL CIVIL AVIATION

8.2 Traditionally, the provision of meteorological information to support international civil aviation was based primarily at the national level and organized hierarchically, with a specific meteorological office designated to be associated with each flight information centre (FIC)/area control centre (ACC), approach control unit and air traffic control tower. The associated meteorological offices supplied selected meteorological information necessary to enable each of the air traffic services units to meet its various obligations.

8.3 The meteorological information provided was related to an FIR and particular aerodromes required as destinations and alternates in that FIR and in immediately adjacent FIRs. Communication of this information beyond the FIRs concerned was tightly controlled so as not to overload the AFTN unnecessarily. The meteorological information was provided to pilots, *inter alia*, in face-to-face briefings in an airport meteorological office, using controller/pilot voice communications and through the automatic terminal information service (ATIS) and HF/VHF meteorological information for aircraft in flight (VOLMET) broadcasts.

8.4 It was inevitable, however, that the fundamental changes in international civil aviation in the 1980s, such as deregulation, increased air traffic and longer, direct flights, and the increased associated costs of the provision of facilities and services, which essentially prompted the creation of CNS/ATM systems, would also drive a parallel need for changes in the provision of meteorological services for international civil aviation.

8.5 These changes in the provision of meteorological services, which began in the early 1980s, comprised two main elements. The first was the development of the ICAO world area forecast system (WAFS) which, initially, centralized the production of global upper wind and temperature forecasts by two world area forecast centres (WAFCs), along with the production of significant weather (SIGWX) forecasts and the dissemination to States by fifteen regional area forecast centres (RAFCs) of WAFC- and RAFC-produced charts. The second element concerned the gradual change in the content and format of the meteorological information provided to pilots and a relaxation of the rules governing the exchange of operational meteorological information (OPMET) messages to permit a wider distribution.

8.6 In the recent past, changes which had generally progressed steadily over the previous decade began to accelerate markedly. This was not due to any sudden change in the operational requirements — essentially these were still being driven by the explosive growth in global air traffic and the need for cost-effective means to satisfy the attendant requirements — but by the technological developments in computing and telecommunications. These developments made possible a complete rethinking of the ways and means of providing the required meteorological facilities and services in a cost-effective manner, while at the same time improving safety. Taking advantage of these technological developments so that aviation meteorology contributes effectively to the smooth transition to global CNS/ATM systems is the challenge facing the international meteorological community today.

METEOROLOGICAL SYSTEMS TO SUPPORT GLOBAL CNS/ATM

8.7 The need for aviation meteorology to think increasingly in terms of global rather than regional or national concepts had already been foreshadowed in the development of the WAFS and in the changes made to the content, format and exchange pattern of OPMET messages. In fact, the original concept of the WAFS, as approved by the ICAO Council, included a final phase in which all WAFS data and products would be produced by computer at the two WAFCs, with global dissemination of the information direct from the WAFCs to States by satellite broadcast. The rapid developments in computer technology and associated forecasting techniques, and satellite broadcasting technology have rendered it possible to plan for the final phase of the WAFS much earlier than had hitherto been anticipated. In parallel with these developments, the introduction of a data link has permitted, for the first time, the automated uplink of meteorological information direct to the cockpit, either at the initiation of the ATM system or in response to the pilot's request, and the automated downlink of data from the aircraft including wind and temperature, turbulence and humidity.

8.8 Two other components of the global meteorological system are the ICAO international airways volcano watch (IAVW) and the ICAO tropical cyclone warning system, both of which are of particular importance for international air navigation since volcanic ash and tropical cyclones are the only weather phenomena which would normally result in the cancellation of a flight at the pre-flight planning stage. The IAVW was initially introduced to be operated on a voluntary basis but has since been consolidated into a well-structured global system consisting of nine volcanic ash advisory centres (VAACs) which issue volcanic ash advisories both in alphanumeric and graphical formats to be used by MWOs for issuing SIGMET messages, by international NOTAM offices for the issuance of NOTAMs for volcanic ash and ASHTAMs, by ATM for re-routing and activation of contingency arrangements, and by operators for pre-flight and in-flight planning. The ICAO tropical cyclone warning system was established consisting of six tropical cyclone advisory centres (TCACs) which issue tropical cyclone advisories to be used by MWOs for issuing SIGMET messages, by ATM for re-routing and activation of contingency arrangements, and by operators for pre-flight and in-flight planning.

8.9 In a limited way, ATM is already employing additional and enhanced meteorological information made possible by the aforementioned technological advances in meteorological systems. The application of these systems to current operations is focused mainly on specific elements of ATM, where it can be demonstrated that the provision of enhanced or additional meteorological data and products is either critical to the operation concerned or provides a cost-benefit. An example of this is the provision of additional and enhanced meteorological information to support the following:

- the provision of medium-level SIGWX forecasts and en-route diversion aerodrome reports and forecasts for one-engine inoperative drift-down procedures for extended range operations;
- the provision of the latest SIGMETs and upper wind/temperature data from meteorological watch offices (MWOs) and WAFCs respectively, direct to ATC computers, for updating flight plans for dynamic aircraft routing over the Pacific Ocean;
- the daily selection of the organized tracks over the North Atlantic based upon upper wind fields produced by the WAFCs; and
- the use of real-time information on hazardous en-route and destination weather and updated upper wind fields for air traffic flow control.

8.10 All of the examples provided in the previous paragraphs concern pre-flight planning and en-route operations. These depend upon the WAFS, direct satellite broadcasts, and the direct and preferably automated provision of updated meteorological forecasts or real-time data to ATC. But examples need not be restricted to en-route operations. In the terminal area, the advent of data link has already spurred the development of systems for the automated provision of meteorological information direct to aircraft, some examples of which are:

- uplink of reports from automatic weather observing stations;
- uplink of wind shear/microburst warnings from automated terminal Doppler weather radar (TDWR); and
- automatic downlink of wind/temperature data from aircraft on approach and during climb-out.

METEOROLOGICAL SYSTEMS TO SUPPORT THE TRANSITION TO THE NEW GLOBAL CNS/ATM SYSTEMS

8.11 In order to support and facilitate the transition to CNS/ATM systems, the meteorological systems described in the foregoing paragraphs will have to be further developed and more focused on global requirements, in addition to national and regional requirements. These developments must meet aeronautical requirements to improve safety and provide an identifiable cost-benefit to users. The systems must converge, as much as possible to create a seamless and transparent global meteorological system for the provision of meteorological service to international civil aviation.

8.12 In many respects the WAFS and the ICAO direct satellite broadcasts have already made the transition to a seamless and transparent system, which, moreover, is also converging with systems for the exchange of OPMET messages. The global ATM system will require access to global meteorological information on a far shorter timescale than has been customary in the past. In many cases, virtual "instant" access, including real-time data, will be required. Such stringent requirements will dictate that as many of the processes as possible, which the systems comprise, must be automated. The meteorologists' input will be increasingly transferred to the beginning of the processes, even to the extent of transferring knowledge and experience through artificial intelligence to dedicated expert systems.

8.13 Development of the meteorological systems to support a global ATM system will be required specifically in the following areas:

a) rapid progress to the final phase of the WAFS with two WAFCs producing automated global upper winds/temperatures and SIGWX forecasts, which may be input directly into ATC and airline computers. The final phase is expected to be implemented by 2002;

b) continued extension of the three ICAO direct satellite broadcasts to exchange global OPMET messages and, as necessary, other non-MET aeronautical information;

c) availability at ATC centres and airline centralized operational control of background upper wind fields for display, both in the form of WAFS global upper wind forecasts and "real-time" wind fields derived from the wind information reported automatically from an aircraft in ADS messages; and reports and forecasts of hazardous weather, particularly volcanic ash, thunderstorms, clear-air turbulence and icing, to assist in tactical decision-making for aircraft surveillance, air traffic flow management, and updating flight plans for flexible/dynamic aircraft routing;

d) automatic uplink of aerodrome weather observations to aircraft on approach or departure, including D-ATIS and D-VOLMET to replace HF and VHF VOLMET; and dedicated systems to detect hazardous weather, such as automated terminal Doppler weather radar (TDWR);

e) automatic downlink of meteorological information derived from aircraft sensors (wind, temperature, turbulence and humidity) to ATC computers to provide background upper wind fields, as described above, and real-time descent wind profiles to assist in the automatic sequencing of aircraft on approach to maximize runway capacity; and relay of this information to the two WAFCs for assimilation in global numerical weather prediction models, thereby improving the overall quality of subsequent global forecasts;

f) use of meteorological sensors, including Doppler radar, possibly providing input to expert systems, which will provide automated runway wake vortex reports and forecasts to assist in optimizing aircraft separation, thereby maximizing runway capacity;

g) full implementation of the IAVW, which would result in a reduction in the time-delay for volcanic ash reports and advisories and associated SIGMETs from volcano observatories, volcanic ash advisory centres (VAACs) and meteorological watch offices to reach area control centres and aircraft in flight by employing more direct routing; and

h) harmonized common point of access to aeronautical information services (AIS) and meteorological services for air navigation meteorological information to support combined automated AIS/MET pre-flight briefing facilities.

PLANNING AND IMPLEMENTATION OF METEOROLOGICAL SYSTEMS

8.14 All of the foregoing elements are either currently in existence and being further developed or are the subject of research and development by States. The implementation of these elements to form a seamless global system will proceed step by step as aeronautical requirements for the service are stated and reflected, as appropriate, in the relevant ICAO SARPs. This is critical in order to indicate clearly that the service is required by international civil aviation to contribute to the maintenance or improvement in air safety and/or provide a demonstrated cost-benefit to users associated with global ATM. Once the requirements are firmly established, standardization of the relevant meteorological facilities and services will facilitate the planning of a seamless and transparent meteorological system to support the global ATM system.

8.15 In planning for the implementation of meteorological systems, account has to be taken of the existing national, regional and global meteorological and telecommunications infrastructures and a determination made as to which parts will be able to support the global ATM system and which will need to be upgraded or replaced.

8.16 Clarification will be needed concerning the optimum balance between the required meteorological information being "pushed" to the aircraft from the ground and being "pulled" to the aircraft by pilot request. How, in which form and where the global meteorological information will best be routed and concentrated will be very much dependent upon receiving this clarification as early as possible in the planning process. In general, it would seem that, in the future, increasing emphasis will be placed on "routine" meteorological information being accessible by the pilot automatically upon demand, with directed or broadcast transmissions being restricted mainly to safety-related information. Making information accessible to the pilot may be achieved in practice either by having it uplinked and stored in the aircraft computers or stored on the ground in OPMET databases and/or servers which can be interrogated by the pilot. The optimum balance between the meteorological information broadcast directed from the ground to the aircraft, and meteorological information obtained by pilots interrogating OPMET databases must emerge from the development of the operational requirements, which will then be reflected in the pattern of global OPMET exchange requirements.

Chapter 9

AERONAUTICAL INFORMATION SERVICES

REFERENCES

Annex 4 — *Aeronautical Charts*
Annex 15 — *Aeronautical Information Services*
Procedures for Air Navigation Services — ICAO Abbreviations and Codes (PANS-ABC, Doc 8400)
Aeronautical Chart Manual (Doc 8697)
Aeronautical Information Services Manual (Doc 8126)
World Geodetic System — 1984 (WGS-84) Manual (Doc 9674)

INTRODUCTION

9.1 This chapter describes how aeronautical information services (AIS) and aeronautical charts (MAP) have traditionally been provided and the need for a new approach to support global air traffic management systems and their associated automation systems. This chapter also outlines the necessary developments in AIS and MAP as well as the ways and means of collecting, preparing, validating, organizing and distributing aeronautical information in support of air traffic management.

AIS AND MAP SUPPORT TO INTERNATIONAL CIVIL AVIATION

9.2 The major objective of AIS is to ensure the flow of information necessary for the safety, regularity and efficiency of international civil aviation. In that respect, each Contracting State is required to provide this service and is responsible for the information provided. Traditionally, aeronautical information has been provided as hard-copy documents in the form of the Integrated Aeronautical Information Package, which contains information for the entire territory and also areas outside the territory for which a State is responsible for the provision of air traffic services. The information must be provided in a suitable form and must be of high quality, be timely and include, as necessary, aeronautical information of other States. In addition, pre-flight and in-flight information services must be provided.

9.3 To satisfy the requirements of flight operations, aeronautical information/data necessary for the safety, regularity and efficiency of air navigation must be made available to personnel, including flight crews and those involved with flight planning, flight simulation and air traffic services and to units responsible for flight information services.

9.4 The role and importance of aeronautical information/data has changed significantly with the implementation of RNAV, RNP and airborne computer-based navigation systems. These systems are all data-dependent, and in that respect aeronautical data have become the necessary critical components of the system. Consequently, corrupt or erroneous aeronautical information/data can potentially affect the safety of air navigation. In this respect, as of 1 January 1998, each Contracting State must take the necessary measures to introduce a properly organized quality system containing procedures, processes and resources necessary to implement quality management at each functional stage of the data process. Quality systems must provide users with the assurance and confidence that distributed aeronautical information/data satisfy established requirements for data quality (accuracy, resolution and integrity) and timeliness.

9.5 For the safe performance of air operations, it is essential that current, comprehensive and authoritative navigation data be available at all times, and that aeronautical charts supply that information in a manageable and condensed manner. Considering that all segments of aviation make reference to aeronautical charts for air traffic control, planning and navigation purposes, it is of prime importance to place current and accurate charts in the hands of users.

9.6 Current practices require Contracting States to ensure the availability of specific charts either by producing the charts themselves or arranging for their production by another State, or by an agency which would then be provided with the necessary data. International specifications are required in order to achieve the safety, regularity and efficiency of international air navigation by specifying the types of charts to be made available and by ensuring the adequate uniformity of the charts. The increased speed of aircraft, together with a greater range in operating altitudes and route stages, and increasing air traffic congestion impose requirements for rapid chart interpretation and some latitude for improvements in chart design to meet changing operational needs. In addition, the effective functioning of AIS pre-flight information units is partly dependent upon the availability of aeronautical charts for flight planning. Finally, the aeronautical information services are required to publish in their Aeronautical Information Publications (AIPs) a description and list of available aeronautical charts series, together with an indication of their intended use.

9.7 The provision of aeronautical information and aeronautical charts services to support international civil aviation is primarily the responsibility of States. The aeronautical information provided is related to the FIR and aerodromes within a given region. This information is provided to pilots in face-to-face briefings at the aerodrome AIS unit or in flight, through air traffic control. Communication of the latest information to users is effected through the aeronautical fixed telecommunication network (AFTN) in the form of notices to airmen (NOTAM). So far, automation of the AIS has been basically oriented toward the NOTAM system, and planning has taken place at the regional level. With the adoption of CNS/ATM systems by international civil aviation, new requirements for aeronautical information and charts services have emerged. These new requirements are driven by the growth in global air traffic and the need for cost-effective solutions, as well as the technological developments in computing and telecommunications. It is therefore essential that in the interest of safety and efficiency of civil aviation, AIS and MAP services contribute effectively to the transition to global CNS/ATM systems by developing further specifications and conditions to satisfy these new operational requirements.

AIS AND MAP SERVICES TO SUPPORT GLOBAL CNS/ATM SYSTEMS

9.8 For CNS systems to operate and generate the full benefits of their use through enhanced ATM, the support of other services such as AIS and MAP is essential. In this respect, the enhanced ATM system, along with the requirement for precise navigation capability, will require quality aeronautical information so as to be able to provide guidance for gate-to-gate operations* between origin and destination. This will include the ability of aircraft to navigate on the ground and en route, using on-board navigation systems that can calculate desired tracks.

9.9 With the increased quantity of aeronautical information and with the clearly defined operational requirement for aeronautical data quality (accuracy, resolution and integrity), emerging aeronautical databases are improving, *inter alia*, the speed, efficiency and cost-effectiveness of aeronautical information. For these reasons, many States have begun or are planning to develop electronic aeronautical databases with the intent of using such data to prepare and update their AIPs and/or to exchange electronic aeronautical information. It is therefore necessary to develop new Annex 15 specifications related to the electronic storage, provision and interrogation of aeronautical information. These new specifications should provide neutral international Standards on the basis of which an ICAO Conceptual Information Data Model will be developed. To satisfy the operational requirements for the exchange of aeronautical data while taking into account the compatibility of different systems and formats, a new data exchange model is also required.

9.10 The 1990s witnessed a revolution in the way aeronautical information is processed, integrated and presented to pilots and other users. The technology is available today to display a viable electronic chart in the cockpit, thereby substantially reducing the need for paper charts. The real need, however, is for more than just an electronic page turner that replaces a paper chart book. The future electronic chart must be intuitive and designed to simplify the pilot's interpretation tasks, while minimizing information overload by reducing the amount of displayed data. It must also provide pilots with the option of accessing only the specific data required for a particular phase of flight. As charted aeronautical information symbology is gradually transferred from paper to electronic form, a degree of standardization of the symbology to be used in electronic chart displays will be required. Some of these Standards have already been developed and included in Annex 4; however, further development is in progress.

9.11 In order to provide worldwide standardization of the charting information necessary for aircraft to use GNSS, some new charting specifications have also been introduced into Annex 4, and the development of the complete specifications continues.

9.12 It is important that terrain and obstacle information be available and accurately presented on electronic aeronautical charts. Users' requirements for the quality and format of electronic terrain and obstacle data must be taken into account in addition to how this information can best be

* Emerging concept or technology — consensus still to be reached.

consolidated with aeronautical information and presented on electronic charts. Annex 4 specifications are being developed to ensure that they facilitate and standardize the provision of electronic terrain and obstacle information, which meets user requirements while taking into account quality assurance.

9.13 New Annex 15 specifications dealing with the exchange of electronic aeronautical data through the use of available and new technological means are under development as well. In addition, data link communications as specified for CNS/ATM systems will replace most voice communications of aeronautical information currently disseminated by ATS. Once a sufficient number of aircraft are capable of air-ground data link communications and aeronautical databases are made available, pilots will be able to access and interrogate those databases at various stages of flight. Worldwide standardization of the communication and display of these data is deemed necessary, which will include aspects of surface-to-surface as well as data link communications to facilitate interrogation of aeronautical information from aircraft. New Annex 15 Standards will also include procedures for aeronautical data transfer, taking into account data formats and data protection during the transfer.

9.14 The ICAO *Training Manual*, Part E-3 — *Aeronautical Information Services Personnel* (Doc 7192) is being updated, and an ICAO training programme for AIS/MAP personnel is being developed. The programme will include training curricula for AIS/MAP technical officers and will establish uniform Standards for the qualifications and scope of knowledge that must be met by all AIS/MAP technical officers worldwide. The material will be based on the recently updated operational requirements for the provision of quality aeronautical information necessary for the safety, regularity and efficiency of international air navigation. As a result of the increased responsibility of AIS/MAP personnel to provide quality aeronautical information, there may eventually be a need to license certain AIS/MAP personnel.

AIS/MAP SYSTEMS TO SUPPORT THE TRANSITION TO THE NEW GLOBAL CNS/ATM SYSTEMS

9.15 In order to support and facilitate the transition to new global CNS/ATM systems, the aeronautical information and charts systems will be further developed and oriented more towards global requirements, in addition to national and regional requirements. This should be done in such a way that would safely increase efficiency and cost-effectiveness to users. The goal, as far as possible, is the creation of a seamless and transparent global aeronautical information system.

9.16 It is envisaged that the global ATM system will require global aeronautical information of a required quality. The ultimate goal would be to provide on-line, in real-time, quality aeronautical information to any user, any time, anywhere. To achieve this high-level goal, aeronautical information must be provided and exchanged in electronic form based on a conceptually standardized data model. Strict quality principles must be in place to ensure that aeronautical data are available, verified and validated in order to give the end-user confidence in the correctness of the information.

9.17 Development of aeronautical information systems to support global ATM is specifically required in the following areas:

a) completion by States of implementation of the World Geodetic System — 1984 (WGS-84) common geodetic datum adopted for international civil aviation;

b) implementation by States of a quality system for the origination, production, maintenance and distribution of aeronautical information;

c) development and introduction of an ICAO conceptual information data model for the storage, retrieval and exchange of aeronautical data;

d) extension of the broadcast of aeronautical information through satellites to enable exchange of aeronautical data, in textual and graphical form, and messages associated with the status of ground-based databases;

e) development of specifications for the direct uplink of aeronautical information (including charts) into aircraft, along with the possibility for interrogation, from the aircraft, of aeronautical databases on the ground; and

f) implementation of a common point of access for AIS, MET and flight plan (FPL) information to support combined automated AIS/MET/FPL pre-flight and in-flight briefing facilities.

Chapter 10

HUMAN RESOURCE DEVELOPMENT AND TRAINING NEEDS

REFERENCES

Report of the World-wide CNS/ATM Systems Implementation Conference (Doc 9719)

INTRODUCTION

10.1 A major goal of CNS/ATM systems is to create a seamless global air navigation system. A seamless air navigation environment will require an international team that is prepared to perform their jobs in such an environment. To achieve this, it is essential that personnel who will form this team receive a consistent, quality level of training throughout the world.

10.2 The evolution of aviation technologies has been gradual in the past, and trainers have, for the most part, been able to meet the challenges associated with change even though sophisticated training methodologies and tools have not always been at their disposal. However, the new CNS/ATM systems are based on many new concepts, and their implementation presents a greater challenge to trainers.

10.3 ICAO undertook an initial study to assess the training implications of CNS/ATM systems. The objective of the study was to gain an early understanding of the amount of training that would be required by analysing the degree to which basic job disciplines in the aviation system will change with the introduction of the new technologies. While this was only a preliminary study, the results indicated that:

a) many aviation disciplines will change as a result of the introduction of CNS/ATM technologies, and it is likely that re-training will be required for a number of these disciplines. The most important changes seem to result from an increased use of computers, data communications and automation;

b) the change from ground to satellite-based technology will mean that several aviation disciplines will no longer be needed. At the same time, new aviation disciplines will emerge as a result of the introduction of CNS/ATM systems. From a human resource planning standpoint, there will be a need for re-deployment and training of personnel; and

c) the need for training and course development will be especially high during the transition phase. Not only will a large number of personnel have to be trained or re-trained on new technologies, equipment and procedures, but a sufficient number of qualified personnel will need to remain proficient in the skills necessary to operate and maintain the older systems.

10.4 CNS/ATM systems training needs can be seen as falling into three primary categories.

a) **Foundation training**. Early training in the fundamentals of automation, digital communications, satellite communications and computer networking is needed to provide all civil aviation personnel with the prerequisite skills prior to receiving job-specific training;

b) **Training for implementation planners**. Training is needed at a senior management level to provide decision-makers with the basic information needed to begin planning for implementation of CNS/ATM systems. This type of training is needed for managers who will plan the implementation of CNS systems, as well as those managers who will be responsible for planning the ATM operational aspects of the systems; and

c) **Job-specific training**. The third category of training needed is that necessary for personnel to manage, operate and maintain the systems on an ongoing basis. This category also represents the bulk of the training needed and the most complex to design, develop and implement. Taking this into consideration, ICAO has developed a strategy for the development of training programmes, as described in this chapter.

10.5 The first two categories of training described above should be implemented as soon as possible and are described in more detail below. A long-term strategy for development of the job-specific training needed to manage, operate and maintain CNS/ATM systems on an ongoing basis, is also outlined below.

FOUNDATION TRAINING

10.6 In addition to the usual subjects covered in typical civil aviation training centres, some additional foundation or prerequisite training will be necessary. This training will ensure that all personnel who will be involved with the planning, implementation, management, operation and maintenance of the new systems have an appropriate background in the base concepts and technologies. Such foundation training should be developed so that it addresses the specific needs of the technical and operational planners, as well as all personnel that will eventually be involved in the operation, maintenance and management of the new systems. The training needs include the following general areas:

a) CNS/ATM systems;

b) digital communications;

c) computer fundamentals;

d) computer communications, including local/wide area networks;

e) ISO-OSI reference model;

f) satellite communications systems used for fixed and mobile applications;

g) satellite navigation systems;

h) automation issues;

i) fundamentals of air traffic management; and

j) aeronautical databases.

CNS SYSTEMS IMPLEMENTATION PLANNING — TRAINING NEEDS

10.7 The existing communications, navigation and surveillance systems have mostly been planned, implemented and operated by individual States. The new CNS/ATM systems, however, are global in nature and as such are usually planned and implemented at a regional or global level. Regional implementation can be carried out by collective regional entities or commercial service suppliers. As a result, many States can simply buy CNS services with a minimum of local implementation of the systems.

10.8 Given the modality for the implementation of the technical systems, the technical management personnel of civil aviation administrations (CAAs) will need to become familiar with the major functions and features of CNS systems, as well as the implementation, leasing and purchasing options available. They should then examine various options for systems implementation with their ATM colleagues and jointly decide upon their transition strategy. In this regard, training that provides an overview of the following CNS systems should be provided for senior technical management personnel:

a) communications: AMSS, VDL, SSR Mode S datalink, HF datalink and ATN;

b) navigation: GNSS, including standard augmentation systems;

c) surveillance: SSR Modes A, C and S, ADS, ADS-B* and ASAS*; and

d) relevant organizational, economic, certification and operational matters.

ATM OPERATIONAL IMPLEMENTATION PLANNING — TRAINING NEEDS

10.9 Senior operational managers involved with transition planning to the new systems will need an overview of the topics listed above. In addition, operational managers should receive training in the following areas:

a) traffic forecasting and cost-benefit analysis techniques;

b) air traffic management;

   1) airspace planning;

   2) ATFM systems and procedures;

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* Emerging concept or technology — consensus still to be reached.

3) ATS systems and procedures; and

4) ATM-related aspects of flight operations;

c) CNS/ATM transition and implementation project planning;

d) human resource planning and training issues;

e) issues related to the increased use of automation in the new systems; and

f) operational and quality control issues associated with aeronautical databases.

10.10 Because the existing systems will be operated in parallel with the new systems for a period of time, human resource planning and training will be a major challenge during the transition period.

10.11 CNS/ATM systems will result in a greater use of automation in many of the air traffic control functions that were previously performed manually. As a result, interactions between controllers and flight crews will take on a different dimension. Thus, it is important that the operational planners receive early training in these issues, including the full implications of automation, including backup procedures to be used in the event of system malfunctions. This area of training will also be important during the job-specific training for anyone involved in the operation of CNS/ATM systems.

A LONG-TERM STRATEGY FOR CNS/ATM JOB-SPECIFIC TRAINING

10.12 The Standing Policy of ICAO on aviation training, as contained in Assembly Resolution A31-5, Appendix H, forms the basis for the long-term CNS/ATM training strategy. The ICAO Aviation Training Policy is governed by three basic principles. First, aviation training is the responsibility of Contracting States. Second, the ICAO Aviation Training Programme shall encourage mutual assistance among Contracting States in the training of aviation personnel. Finally, the Organization does not directly participate in the operation of training institutions, but encourages and advises the Contracting States operating such facilities.

10.13 Much progress has been made in the establishment and ongoing development of national and regional civil aviation training centres. However, shortcomings in human resource planning and training are still frequently cited as important reasons for the lack of implementation of regional air navigation plans. It is anticipated that this problem could be further exacerbated with the implementation of CNS/ATM systems.

10.14 In the past, training programmes for the existing air navigation systems were, for the most part, developed and implemented independently by each State's civil aviation training institution. Given the magnitude of change in civil aviation jobs and the resulting training requirements (10.3 refers), it is anticipated that civil aviation training institutions, working individually or on an ad hoc basis, will not be able to develop all of the training programmes necessary for timely implementation of CNS/ATM systems. Independent development of the CNS/ATM course materials would also tend to defeat the ICAO goal of standardizing the curricula, methods and content of training. A coordinated and cooperative approach towards CNS/ATM training development would help to achieve both the goal of timely training development and standardization, and would also be more efficient insofar as it could help to prevent duplication of effort that has occurred in the past. The strategy as outlined below consists of three basic elements and is designed to facilitate international cooperation in the development of CNS/ATM training materials.

a) **Early identification of CNS/ATM training needs and priorities.** Given the considerable amount of training that will need to be developed for the new systems, as well as the need for training standardization, it is imperative that a plan be established for the cooperative development of the required course materials. However, an effective and cost-efficient plan can only be formulated once CNS/ATM training needs and priorities are clearly identified. As in any systematic approach towards project management, the tasks must first be defined and prioritized before they can be effectively allocated to the entities that will perform the work;

b) **Coordination and planning of CNS/ATM training development at the regional level.** The actual planning and coordination in the development of CNS/ATM course materials should be carried out at a regional level. There are existing structures within the regions that would be appropriate for this type of coordination. Moreover, experience has already been gained in this approach as it is being used, to some extent, in several ICAO regions. While human resource planning and training coordination have improved as a result of existing regionally coordinated efforts, there are still shortcomings in this area. A high level of regional coordination and planning is particularly important in the development of specialized courses where the number of trainees does not justify the implementation of courses in each State's national training centre; and

c) **Widest possible participation in the TRAINAIR Programme by States.** In 1990, ICAO established the TRAINAIR Programme to enhance training in civil aviation. The programme offers an existing framework for global coordination and harmonization in training development. The use of the TRAINAIR standardized course development methodology ensures that the training packages developed by members will have the widest possible global use. The Programme also has a well-established and proven network for the cost-efficient sharing of course materials produced by members. The TRAINAIR Programme could further improve the effectiveness and efficiency of CNS/ATM course development through the use of its methodology and by providing global coordination and harmonization between the regions as they develop CNS/ATM training materials.

10.15 The first two strategies described above will be facilitated through an ICAO Air Navigation Commission (ANC) task established during 1996 involving regional human resource planning and training needs. An objective of this task is to analyse the changes to civil aviation job profiles as a result of new systems, and the consequential human resource planning and training requirements. In addition, the task will also develop a model for human resource planning and training for use at the regional level, as well as supporting guidance material.

REGIONAL HUMAN RESOURCE PLANNING AND TRAINING NEEDS

10.16 ICAO is preparing guidance material that will assist States in planning for the human resources and training needed for CNS/ATM systems, as well as for existing systems. Most of the ICAO regions already have regional forums to discuss and plan for the regional training needs. The outputs of this task will enhance the existing regional planning processes by providing a consistent approach for use by all regions.

10.17 It is expected that this ANC task will produce two major outputs. The first output would be a human resource planning manual for use by States. The manual will include tables that will assist States in determining current and projected personnel needs. The planning tables will take into consideration the needs that emerge as a result of the implementation of CNS/ATM systems and will also allow for the insertion of variables so as to reflect local policies.

10.18 The second major output would be a model for planning regional training capabilities. The model would provide a systematic methodology for analysing human resources plans; determining the needs for national and/or regional training capabilities; and documenting the results. The resulting training plans could be stand-alone documents or incorporated into the regional ANPs. As a part of ICAO's work programme, a study group could then review the appropriateness of including human resource and/or training planning information in the regional ANPs.

SOURCES OF TRAINING

10.19 The regional human resource planning and training needs task will provide a systematic approach towards determining the need for national and/or regional training capabilities. The results of this analysis may be published as a stand-alone document or incorporated into the regional ANPs. This document, whether stand-alone or as part of an ANP, will provide States with the information needed concerning current training capabilities planned within their regions in CNS/ATM areas.

10.20 Training opportunities that are offered to international trainees on a global basis are already listed in the ICAO Training Directory. Courses that provide training in CNS/ATM systems are now identified within the course descriptions by the statement "CNS/ATM Content."

10.21 TRAINAIR member civil aviation training centres are also developing courses that address CNS/ATM systems training needs. As mentioned above, TRAINAIR offers an existing framework for the global coordination and harmonization of training development. Members share the courses, or standardized training packages (STPs), that they develop using the TRAINAIR training development methodology. This system is very efficient as members can acquire STPs prepared by other members at a cost that is not to exceed the actual cost of reproduction and postage. Almost all course materials are produced on the computer and the members now share electronic versions of the courses. This greatly reduces the cost of acquiring STPs from other members. Members will also begin to share STPs using the Internet, which will once again reduce cost and allow easier access to the materials.

10.22 TRAINAIR membership is open to all government-operated civil aviation training centres.

Participation by other civil aviation training centres is under review. One of the major requirements of TRAINAIR membership is to establish and maintain a Course Development Unit that is dedicated to preparing STPs to TRAINAIR Standards. As a Course Development Unit's start-up costs typically exceed the resources available within a developing State's training centre's budget, these costs are normally funded through ICAO technical cooperation projects.

10.23 ICAO's Technical Co-operation Programme can also assist in the development of training capabilities and the funding of fellowships for international training through Technical Co-operation Projects. Additional information concerning the ICAO Technical Co-operation Programme is provided in Part I, Chapter 15.

HUMAN RESOURCE DEVELOPMENT DURING TRANSITION

10.24 Human resource development is an area of particular importance when considering transition to CNS/ATM systems. The main function of human resource development is to help organizations meet the challenges created by change, to adapt to new requirements and to achieve the levels of human performance needed. The transition to CNS/ATM systems represents significant change. As a result of this change, human resource development managers will need to review organizational structures, plan for the human resources needed, review selection criteria for new staff and plan for the development of new training programmes.

10.25 As an integral part of transition planning, each service provider should include a review of its organizational structure. CNS/ATM systems are global in nature and usually planned and implemented at a regional or global level, in some cases by collective regional entities or commercial service suppliers. This may mean that a State's service provider's organizational structure may need to change in order to adapt to these conditions. The changes to job profiles, elimination of some types of jobs and creation of new jobs as a result of the new technologies will also cause changes that may need to be reflected in organizational structures.

10.26 The aim of human resource planning is to ensure that the operational organizations have the right number of people at the right time and with the right skills. As a result of technological changes and the lead time required to train personnel, human resource planning is one of the major challenges faced by civil aviation managers. Human resource planning has a direct effect on training, as one of its outputs is a training demand forecast. This forecast is an essential element in the preparation of a training programme. It provides an estimate of both the number of staff to be trained and the broad types of training required.

10.27 Planners will need to take the following human resource planning factors into consideration:

a) there are several job disciplines that will no longer be required once a State has fully implemented the new systems;

b) there will be new job disciplines as a result of the implementation of the new systems;

c) most of the existing jobs will require additional training for the new systems;

d) there will be a period of time in which the old and new systems will operate in parallel; and

e) much of the training will be in areas that involve a greater use of automation.

10.28 Typically, human resource plans should project needs for at least five years ahead. This period is normally required to provide enough time to re-deploy staff and recruit new staff to other jobs when needed and prepare training as required. As outlined in 10.17, ICAO is developing a manual to assist States in human resource planning. The manual will assist States in projecting human resource requirements for both new and existing technologies.

10.29 The human resource and training requirements during the transition period should be a major focus of CNS/ATM systems implementation planners. From a human resource planning standpoint, the factors listed above can create a complex planning problem. In particular, the need to operate old and new systems in parallel, in combination with an evolutionary transition in which some job disciplines will be eliminated while others will be created, will require careful planning.

10.30 Existing personnel will be involved in much of the training during the transition period. Their time spent in training can have a profound effect on human resource plans and should also be considered. While some of this training can be done using distance learning techniques, there is still a significant amount of training that will need to be done in a training centre. It is expected that the amount of training will peak during the transition period. Typically, staffing will have to be adjusted during this period to account for personnel in training, as well as the operational personnel that may be required to deliver training that is conducted in a training centre and on-the-job training that is conducted in the field.

10.31 It is recommended that States begin the process of planning for the human resources and training needed to implement the new systems as soon as possible. Much of this will depend on regional and national CNS/ATM systems implementation plans. However, it is possible for States to begin a preliminary study that can be used as the basis for creating a human resource plan for the implementation of CNS/ATM systems. An audit of the current staffing needs, as well as a projection for the next five years in established posts, will form an important basis for the formation of the future human resource plans. Most States already perform this type of analysis on an ongoing basis. However, if this analysis has not been done recently, it is highly recommended that it be undertaken as soon as possible. Typically, the analysis begins with an audit of current staffing levels. A projection is then made in all current job categories as to the need for staffing based upon the current deficit or surplus of staff, projected retirements and staff "wastage" over a five-year period. Wastage is defined as staffing losses due to potential reductions in staffing, premature retirements, resignations and deaths. Typically, wastage will be expressed as a percentage and is derived by analysing the historical data for each job category. If historical data is not available, the use of average wastage rate of three per cent per year may be used. A methodology for the conduct of a human resource audit is available from the ICAO Air Navigation Bureau's Personnel Licensing and Training Section.

10.32 Selection criteria for new staff in all jobs should be reviewed as a part of each State's transition planning for the new systems. The introduction of new technologies, especially those using higher levels of automation, will require new sets of skills. To ensure that the majority of the newly hired employees can succeed in training and eventually perform their jobs in a safe and efficient manner, it will be important that they are recruited with appropriate aptitudes, skills and previous education. If the selection criteria are not adjusted to meet the changing needs of the workplace, training then becomes the primary means for selection. Those trainees without the required aptitudes and who do not succeed during training are "screened out". While this approach can serve the same purpose as a selection, it is extremely expensive to maintain. This approach may also make it very difficult to meet the demand for skilled personnel on a timely basis.

10.33 The development of training for automated systems is more difficult than for non-automated systems. One of the primary challenges in developing training for automated systems is to determine how much a trainee will need to know about the underlying technologies in order to use automation safely and efficiently. It is recommended that task analysis techniques be used as the basis of the design for training in automated systems. Course development based on a task analysis can be somewhat more time-consuming than traditional training development techniques. However, typically the resulting training tends to be more effective and ultimately more cost-efficient.

10.34 As mentioned above, some of the training for the new systems could be implemented using distance learning techniques. Implementation of this type of training can be more efficient as it reduces the time spent at a centralized training centre. Training technologies in this area have, over the past few years, improved dramatically. Computer-based training and training over the Internet are becoming more effective and cost-efficient. The foundation training needed to provide all civil aviation personnel with the prerequisite skills for their job-specific training is one area in which distance learning could be used very effectively. Personnel could take this type of training while at their workplaces and thereby reduce the overall amount of time that may be required in a training centre.

10.35 Planners should also be aware that the implementation of a higher level of automation represents a great deal of change to many civil aviation personnel. The training needed to introduce this change should begin as soon as possible by providing a foundation in computers and automation. Frequently, experienced personnel that are learning new concepts related to automation can be resistant to this type of change. The possible resistance to change is another challenge that should be anticipated and addressed by planners.

Chapter 11

LEGAL ISSUES

REFERENCES

Report of the 29th Session of the Legal Committee (Montreal, 4 to 15 July 1994) (Doc 9630)

Report of the First Meeting of the Panel of Legal and Technical Experts on the Establishment of a Legal Framework with Regard to GNSS (Montreal, 25 to 30 November 1996)

Report of the Second Meeting of the Panel of Legal and Technical Experts on the Establishment of a Legal Framework with Regard to GNSS (Montreal, 6 to 10 October 1997)

Report of the Third Meeting of the Panel of Legal and Technical Experts on the Establishment of a Legal Framework with Regard to GNSS (Montreal, 9 to 13 February 1997)

Resolution A32-19, Charter on the Rights and Obligations of States Relating to GNSS Services

Resolution A32-20, Development and elaboration of an appropriate long-term legal framework to govern the implementation of GNSS

INTRODUCTION

11.1 It has been generally agreed that there is no legal obstacle to the implementation of CNS/ATM systems and that there is nothing inherent in CNS/ATM systems that is inconsistent with the Chicago Convention. There is also a consensus that GNSS shall be compatible with the Chicago Convention, its Annexes and other principles of international law.

11.2 Presently, the legal aspects of CNS/ATM systems address issues mainly related to GNSS, which is a key element of ICAO CNS/ATM systems.

11.3 The Council has been considering the question of a legal framework for GNSS, in the form of a new legal instrument, or several instruments of different types, for some time, with the assistance of the Legal Committee, a Panel of Legal and Technical Experts and a Secretariat Study Group. Even though there is no consensus on the form of any new instrument, there has been much discussion on what features it might contain. The primary legal issue considered to require new law is how to secure accessibility and continuity of GNSS services. Corresponding to this issue, the institutional aspects mainly relate to the future operating structures for GNSS. Attention has been devoted to both the legal considerations in respect of the existing systems and to the elaboration of a more complete and lasting legal framework for the long-term future.

11.4 The transitional arrangements with respect to the existing satellite navigation systems are governed by the Chicago Convention and relevant SARPs. In addition, aspects relating to the provision of the GNSS signal-in-space were the subject of the exchange of letters between ICAO and the United States, dated 14 and 27 October 1994, and ICAO and the Russian Federation, dated 4 June and 29 July 1996.

11.5 The Panel of Legal and Technical Experts on the Establishment of a Legal Framework with Regard to GNSS (LTEP), which was established by the ICAO Council on 6 December 1995, has been given the mandate, *inter alia*, to consider the different types and forms of the long-term legal framework for GNSS and to elaborate the legal framework that would respond to certain fundamental principles. The consideration of the legal framework has resulted in consensus on the text of a draft Charter on the Rights and Obligations of States Relating to GNSS Services, which was adopted by the 32nd Session of the Assembly (22 September to 2 October 1998) in the form of Resolution A32-19. (the "Charter", Appendix A to this chapter refers). Consideration of other legal issues has led to 16 Recommendations (Appendix B to this chapter refers). The material in this chapter is intended to assist States in identifying relevant legal issues, which they may encounter in the planning and implementation of CNS/ATM systems.

FUNDAMENTAL PRINCIPLES OF THE GNSS LEGAL FRAMEWORK

11.6 The Charter embodies certain fundamental principles applicable to the implementation and operation of

GNSS. Some of these principles were derived from the Statement of Policy on CNS/ATM Systems Implementation and Operation, adopted by the Council on 9 March 1994 ("Council Statement of 1994"), as well as from the exchange of letters between ICAO and the United States and ICAO and the Russian Federation, respectively. Certain other principles are essentially restatements and elaborations of provisions of the Chicago Convention.

The safety of international civil aviation

11.7 The safety of international civil aviation is a paramount principle embodied in the Preamble and Article 44 (h) of the Chicago Convention. The Charter, described above, provides for a specific reference to this principle in its paragraph 1:

> "States recognize that in the provision and use of GNSS services, the safety of international civil aviation shall be the paramount principle."

Accordingly, the safety of international civil aviation should be fully safeguarded at all times in the operation of GNSS, including during modification to the system.

Universal accessibility without discrimination

11.8 The principle of universal accessibility without discrimination, which is also embodied in the Chicago Convention and ICAO practice, is of particular importance with respect to navigation satellites as compared to communication satellites. In the case of the latter, the existence of multiple providers and commercial competition will provide a natural basis for guaranteed accessibility. In the event of the lack of access to the services of one provider, the users will simply switch to another provider. Furthermore, the major commercial providers of satellite communications services (e.g. Inmarsat) provide in their constitutional instruments the legal guarantees for accessibility to the services without discrimination.

11.9 The case of navigation satellites is somewhat different. In certain cases, aircraft operators and providers of air traffic services have, in the past, relied on navigational signals generated by navigation aids outside their territory and not under their direct control (e.g. Loran, Omega, or shorter range navigation aids). GNSS will intensify such reliance on foreign systems. For the majority of user States, the existing GNSS facilities are controlled and operated by one or several States. For the time being, multiplicity of system providers and commercial competition do not exist in this field. While some consider that the existing systems do not require a separate legal framework, there has been concern among some potential civil users of GNSS and States with respect to the guaranteed access to, and continuity of, such services. Accordingly, the Council Statement of 1994 affirmed explicitly that the principle of universal accessibility without discrimination shall govern the provision of all air navigation services by way of CNS/ATM systems. The principle, which restates and elaborates principles already enshrined in the Chicago Convention, has also been incorporated into the exchange of letters between ICAO and the United States and ICAO and the Russian Federation concerning the provision of GPS and GLONASS.

11.10 The Charter mentioned above provides that every State and aircraft of all States shall have access, on a non-discriminatory basis and under uniform conditions, to the use of GNSS services, including regional augmen-tation systems within the area of coverage of such systems. The term "aircraft" is included in order to ensure that the aircraft of all States will have such access.

11.11 It may be concluded that the principle of universal accessibility without discrimination is now well accepted. The remaining issue is how to render it generally applicable. States in the process of planning and implementation of CNS/ATM systems could, if necessary, provide additional assurances through bilateral agreements or other arrangements to safeguard their accessibility.

Continuity of services

11.12 Closely related to the issue of non-discriminatory access is the issue of the continuity of services. When GNSS becomes the primary means of air navigation and the traditional terrestrial facilities for air navigation will have become obsolete, the discontinuation of GNSS services, if decided unilaterally by the provider State, could theoretically force users to rely on redundant and back-up systems that might not be convenient or economical for an extended period. The provision of GNSS services will always follow the principle of redundancy. GNSS will consist of a menu of options. The options range from an automatic switch to a back-up system on "standby", which will be part of the institutional arrangements, to an institutional guarantee by an international organization which may make alternative services available. In the exchange of letters with ICAO, the United States and the Russian Federation have respectively committed to take all necessary measures to maintain the integrity and reliability of the services and each of them expects that it will be able to provide at least six years' notice prior to termination of its services.

11.13 The Charter states that every State providing GNSS services shall ensure the continuity, availability, integrity, accuracy and reliability of its services, including effective arrangements to minimize the operational impact of system malfunctions or failure, and to achieve expeditious service recovery. States providing services shall ensure that the services are in accordance with ICAO Standards. States shall provide, in due time, aeronautical information on any modification of the GNSS services that may affect the provision of the services.

11.14 The concept of continuity may be understood in either a technical or a legal sense. In the narrower technical sense, continuity may refer to effective arrangements to minimize the operational impact of unavoidable system malfunctions or failure and achieve expeditious service recovery. In a wider legal sense, continuity may also mean the principle that the services are not to be interrupted, modified, altered or terminated for military, budgetary or other non-technical reasons. It is recommended that States provide adequate safeguards to the principle of continuity in both the technical and legal meaning in the implementation and operation of CNS/ATM systems.

11.15 The Chicago Convention and its Annexes already provide Standards for the integrity and reliability of air traffic services, including navigation aids, and additional SARPs for GNSS are being developed.

Respect of State sovereignty

11.16 The principle of complete and exclusive sovereignty of States over the airspace above their territory is a cornerstone of customary international air law, which has been recognized by the Chicago Convention, 1944. The Council Statement of 1994 affirmed that implementation and operation of CNS/ATM systems, which States have undertaken to provide in accordance with Article 28 of the Chicago Convention, shall neither infringe nor impose restrictions upon State sovereignty, authority or responsibility in the control of air navigation and the promulgation and enforcement of safety regulations. The same principle has also been reiterated in the exchange of letters between ICAO and the United States and ICAO and the Russian Federation, respectively. In providing the GPS and GLONASS signals to other States and their operators, the United States and the Russian Federation will not be performing functions under Article 28 of the Chicago Convention, but will only provide navigation aid signals for use in aircraft positioning.

11.17 The implementation of CNS/ATM systems will favour the concept of "seamless airspace" as opposed to airspace divided by FIRs or territorial State boundaries. For example, one ATM facility may cover an entire region, replacing the work of many existing facilities. From a pragmatic point of view, the implementation of GNSS requires that a balance be struck between the need to respect State sovereignty and the need to promote the use of advanced air navigation and ATM technology. A necessary compromise may involve a certain flexibility in the exercise of certain sovereign rights, in particular by entrusting tasks of signal provision and augmentation to foreign States and/or joint agencies or operating structures, in exchange for additional benefits flowing from the public utility services of GNSS. Regional air traffic management arrangements are already functioning, or are under development, in a number of places, and functioning well.

Compatibility of regional arrangements with the global planning and implementation

11.18 The planning and implementation of CNS/ATM systems is a complex, multifaceted, progressive process, which must be carefully monitored and coordinated at the international level. Such a planning and implementation process could not be successful without global coordination. The responsibility of ICAO in this respect has been affirmed in the Council Statement of 1994 and described in Part I, Chapter 2, Appendix A.

11.19 Paragraph 5, subparagraph 2 of the Charter provides that States shall ensure that regional or subregional arrangements are compatible with the principles and rules set out in the Charter and with the global planning and implementation process for GNSS. Since the implementation of CNS/ATM systems is a complex and far-reaching project, it will require that two primary conditions be met: the first is to devise and implement the systems according to a very well-prepared plan; and the second is for all members of the global community to cooperate fully in its realization. Financial resources are limited and should ideally be used to achieve optimum results. Duplication of efforts should be minimized and mutual interference prevented. Regional or subregional arrangements should therefore promote the global integration of the system.

Cooperation and mutual assistance

11.20 Paragraph 7 of the Charter provides that with a view to facilitating global planning and implemen-tation of GNSS, States shall be guided by the principle of cooperation and mutual assistance. Paragraph 8 provides that every State shall conduct its GNSS activities with due regard for the interests of other States.

11.21 These proposed broad principles appear necessary in view of ICAO's objective to achieve a single, integrated, global CNS/ATM system. Since the global system will be a seamless one, with airspace boundaries transparent to users, it will require an unprecedented degree of cooperation among international organizations, States, service providers and users at all levels; local, national, regional and global.

11.22 In the event that the space segments of GNSS encounter technical failure or malfunction, it might be necessary for the owner or controlling entity of the segments to receive cooperation and assistance from other States. ICAO has repeatedly emphasized that States should be guided by the principle of cooperation and mutual assistance.

11.23 For the above reasons, cooperation and mutual assistance are essential in the planning, implementation and operation of CNS/ATM systems. The forms of cooperation may vary, depending upon the situation in particular States or regions.

OTHER LEGAL ISSUES

11.24 In addition to the fundamental principles incorporated into the Charter, there are other legal issues under consideration, such as:

a) certification;

b) liability;

c) administration, financing and cost-recovery; and

d) future operating structures.

In considering these issues, LTEP put forward 16 Recommendations (Appendix B to this chapter refers) which, along with the report on the work of the Panel, were submitted to the 32nd Session of the Assembly of ICAO, through the Legal Commission, for further guidance. In this respect, the 32nd Session of the Assembly adopted Resolution A32-20 (Appendix C to this chapter refers).

Certification

11.25 GNSS, like other air navigation facilities, requires certification by the relevant authorities in order to ensure that it complies with Standards related to the safety of international civil aviation. Recommendations 1 to 8 adopted by LTEP address the issues related to certification (see Appendix B to this chapter).

Liability

11.26 Similar to terrestrial air navigation facilities, GNSS may, due to technical failure, inaccuracy or other reasons, become a cause of damage to aircraft, persons or goods on the ground or in flight. Issues relating to liability have been the subject of detailed discussions in LTEP and are reflected in Recommendations 9 to 11 (see Appendix B to this chapter).

Administration, financing and cost-recovery

11.27 Recommendations 12 to 14 put forward by LTEP are related to the legal aspects of administration, financing and cost-recovery of GNSS services. These recommendations refer, *inter alia*, to GNSS services as an international service for public use, identify the possible options for administrative mechanisms for GNSS, and consider the possible methods of financing GNSS (see Appendix B to this chapter).

Future operating structures for GNSS

11.28 The term "future operating structure" is related to long-term GNSS, rather than the existing systems. It is ICAO's established policy that GNSS should be implemented as an evolutionary progression from existing global navigation satellite systems, including the United States' GPS and the Russian Federation's GLONASS, toward an integrated GNSS over which Contracting States exercise a sufficient level of control on aspects related to its use by civil aviation. Recommendations 15 to 16 put forward by LTEP address the related issues and identify certain possible fields of international action (see Appendix B to this chapter).

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APPENDIX A TO CHAPTER 11

A32-19: CHARTER ON THE RIGHTS AND OBLIGATIONS OF STATES RELATING TO GNSS SERVICES

Whereas Article 44 of the *Convention on International Civil Aviation*, signed on 7 December 1944 (the "Chicago Convention"), mandates the International Civil Aviation Organization (ICAO) to develop the principles and techniques of international air navigation and to foster the planning and development of international air transport;

Whereas the concept of the ICAO communications, navigation and surveillance/air traffic management (CNS/ATM) systems utilizing satellite-based technology was endorsed by States and international organizations at the ICAO Tenth Air Navigation Conference, and was approved by the 29th Session of the Assembly as the ICAO CNS/ATM systems;

Whereas the Global Navigation Satellite System (GNSS), as an important element of the CNS/ATM systems, is intended to provide worldwide coverage and is to be used for aircraft navigation;

Whereas GNSS shall be compatible with international law, including the Chicago Convention, its Annexes and the relevant rules applicable to outer space activities;

Whereas it is appropriate, taking into account current State practice, to establish and affirm the fundamental legal principles governing GNSS; and

Whereas the integrity of any legal framework for the implementation and operation of GNSS requires observance of fundamental principles, which should be established in a Charter;

The Assembly:

Solemnly declares that the following principles of this Charter on the Rights and Obligations of States Relating to GNSS Services shall apply in the implementation and operation of GNSS:

1. States recognize that in the provision and use of GNSS services, the safety of international civil aviation shall be the paramount principle.

2. Every State and aircraft of all States shall have access, on a non-discriminatory basis under uniform conditions, to the use of GNSS services, including regional augmentation systems for aeronautical use within the area of coverage of such systems.

3. a) Every State preserves its authority and responsibility to control operations of aircraft and to enforce safety and other regulations within its sovereign airspace.

   b) The implementation and operation of GNSS shall neither infringe nor impose restrictions upon States' sovereignty, authority or responsibility in the control of air navigation and the promulgation and enforcement of safety regulations. States' authority shall also be preserved in the coordination and control of communications and in the augmentation, as necessary, of satellite-based air navigation services.

4. Every State providing GNSS services, including signals, or under whose jurisdiction such services are provided, shall ensure the continuity, availability, integrity, accuracy and reliability of such services, including effective arrangements to minimize the operational impact of system malfunctions or failure, and to achieve expeditious service recovery. Such State shall ensure that the services are in accordance with ICAO Standards. States shall provide in due time aeronautical information on any modification of the GNSS services that may affect the provision of the services.

5. States shall cooperate to secure the highest practicable degree of uniformity in the provision and operation of GNSS services.

States shall ensure that regional or subregional arrangements are compatible with the principles and rules set out in this Charter and with the global planning and implementation process for GNSS.

6. States recognize that any charges for GNSS services shall be made in accordance with Article 15 of the Chicago Convention.

7. With a view to facilitating global planning and implementation of GNSS, States shall be guided by the principle of cooperation and mutual assistance whether on a bilateral or multilateral basis.

8. Every State shall conduct its GNSS activities with due regard for the interests of other States.

9. Nothing in this Charter shall prevent two or more States from jointly providing GNSS services.

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APPENDIX B TO CHAPTER 11

RECOMMENDATIONS OF LTEP

Certification

Recommendation 1

ICAO SARPs on GNSS should cover the system performance criteria of relevant satellite components, signal-in-space, avionics, ground facilities, training and licensing requirements, and the system as a whole.

Such ICAO SARPs should contain adequate system performance and failure mode information to enable States to reasonably determine the safety impact on their air traffic service.

Recommendation 2

With respect to all ICAO SARPs on GNSS, signal-in-space provider States and provider international organizations should be involved in the proposed ICAO verification and validation process so that SARPs and supporting ICAO documentation will be of high integrity.

Recommendation 3

States providing signals-in-space, or under whose jurisdiction such signals are provided, shall certify the signal-in-space by attesting that it is in conformity with SARPs.

The State having jurisdiction under the Chicago Convention should ensure that avionics, ground facilities and training and licensing requirements comply with ICAO SARPs.

Recommendation 4

States providing signals-in-space, or under whose jurisdiction such signals are provided, should ensure application of ongoing safety management processes, which demonstrate continued compliance with signal-in-space SARPs.

Recommendation 5

States providing signals-in-space, or under whose jurisdiction such signals are provided, should produce a safety management system document using the ICAO forum referred to in Recommendation 8 below. To the extent possible, such document should be consistent as regards format and content. ICAO should distribute such signal-in-space safety management system documentation.

Recommendation 6

Each State should define and ensure the application of safety regulations for the use of the signal-in-space as part of air traffic services in its own airspace.

Recommendation 7

For the purpose of authorization by a State of the use of the signal-in-space in its airspace, additional information, which may be required for such authorization, should be made available and distributed through ICAO. Other sources for obtaining such information may be used, including, *inter alia*, bilateral and multilateral arrangements, Safety Case and NOTAMs.

Recommendation 8

States recognize the central role of ICAO in coordinating the global implementation of GNSS and, in particular:

a) establishing appropriate Standards, Recommended Practices and procedures in accordance with Article 37 of the Chicago Convention in the implementation and operation of GNSS;

b) coordinating and monitoring the implementation of GNSS on a global basis, in accordance with ICAO's regional air navigation plans and global coordinated CNS/ATM systems plan;

c) facilitating the provision of assistance to States with regard to the technical, financial, managerial, legal and cooperative aspects of the implementation of GNSS;

d) coordinating with other organizations in any matter related to GNSS, including the use of frequency spectrum bands in which GNSS constituent elements operate in support of international civil aviation; and

e) carrying out any other function related to GNSS within the framework of the Chicago Convention, including functions under Chapter XV of the Convention.

More specifically, the ICAO forum for exchange of information on GNSS certification could have the following functions:

a) to provide liaison between State ATS providers, regulatory authorities, and signal-in-space providers;

b) to provide liaison between signal-in-space providers and other States with respect to the format and content of safety management system documents;

c) to identify the failure modes of the signal-in-space and their impact on the safety of air traffic services nationally, and to refer them to an appropriate body as determined by the Council;

d) to identify what States require from signal-in-space providers in order to be confident that performance and risks associated with the signal-in-space are adequately managed over the life cycle of the system;

e) to facilitate information-sharing between signal-in-space providers and other States as to the continued compliance with the relevant SARPs, in order to maintain confidence in the reliability of the system.

Liability

Recommendation 9

The following concepts, among other matters, should be considered in relation to the liability regime for GNSS which should be further studied:

a) fair, prompt and adequate compensation;

b) disclaimer of liability;

c) sovereign immunity from jurisdiction;

d) physical damage, economic loss, and mental injury;

e) joint and several liability;

f) recourse action mechanism;

g) channelling of liability;

h) creation of an international fund (as an additional possibility or an option);

i) the two-tier concept, namely strict liability up to a limit to be defined, and fault liability above the ceiling without numerical limits.

Recommendation 10

With regard to the fault liability portion, signals should be recorded for purposes of evidence in accordance with ICAO SARPs.

Recommendation 11

In conducting the studies on the liability regime for GNSS referred to in Recommendation 9, the following matters should, *inter alia*, be taken into account:

a) how liability provisions concerning the operation, provision and use of GNSS services should ensure that damage arising from such services will be compensated in an equitable manner;

b) the vital role of the signal transmitted by navigation satellites for the safety of international civil aviation could raise the question whether disclaimers of liability would be appropriate in the case of navigation satellites, particularly in cases involving accidental death or injury;

c) having due regard to Principles 3 and 4 on the *Draft Charter on the Rights and Obligations of States Relating to GNSS Services*, whether the doctrine of sovereign immunity should be excluded in liability claims based on GNSS so as to ensure adequate allocation of liability;

d) the practical experience in the commercialization of GNSS services as they develop;

e) appropriate methods of risk coverage should be utilized so as to prevent the frustration of legitimate claims;

f) whether and to what extent liability provisions should reflect the joint liability of all parties involved in the operation, provision and use of GNSS services;

g) liability provisions should have due regard to and, where necessary, should supplement existing principles and rules of international law, including air and space law.

Administration, Financing and Cost-recovery

Recommendation 12

GNSS services should be considered as an international service for public use with guarantees for accessibility, continuity and quality of the services.

The principle of cooperation and mutual assistance, as enunciated in the *Draft Charter on the Rights and Obligations of States Relating to GNSS Services*, should be applicable, *a fortiori*, to the cost-recovery of GNSS.

Recommendation 13

In the absence of a competitive environment regarding the provision of GNSS services, consideration should be given as to whether mechanisms should be desirable to prevent abuse of monopoly power on the part of GNSS providers.

The administrative mechanisms for GNSS should be at multilateral, regional and national levels. The Danish-Icelandic Joint Financing Agreement could be a model but this would not exclude the use of other types of mechanisms, including existing regional arrangements.

Cost-recovery schemes, if any, should ensure the reasonable allocation of costs among civil aviation users themselves and among civil aviation users and other system users.

Recommendation 14

The aviation user charges, which may be considered as possible methods for financing of GNSS, include the following:

a) yearly subscription charges per using operator;

b) yearly subscription charges per using aircraft;

c) yearly/monthly licence fees;

d) charges per flight;

e) charges in respect of different phases of flight;

f) charges based on total passenger-kilometres and tonne-kilometres;

g) regular en-route charges; or

h) a combination of the above.

The principles recommended in the ANSEP Report and in the ICAO Guidelines should in any event be taken into account.

Future Operating Structures

Recommendation 15

The future operating structures should include a coordinating role for ICAO with respect to the future GNSS, including the system providing the primary navigation signals-in-space.

The future GNSS primary signals-in-space should be civilian-controlled, with user States exercising an appropriate level of control over the administration and regulation of those aspects that relate to civil aviation.

To the extent practicable, the future systems should make optimum use of existing organizational structures, modified if necessary, and should be operated in accordance with existing institutional arrangements and legal regulations.

Recommendation 16

National and/or regional operating structures for GNSS should be developed initially. A single centralized operating structure does not appear to be needed at this stage but may be the subject of future study.

International coordination can be achieved through regional organizations operating under the umbrella of ICAO.

Possible fields of international action include:

a) international audit;

b) monitoring of a seamless and universally accessible worldwide GNSS network;

c) monitoring of the stable provision of the international GNSS signals-in-space;

d) signal monitoring of the availability, continuity, accuracy and integrity of the GNSS signals-in-space.

Text on 11 bis*

The Panel recommends to the Council that:

- it should encourage the study of the concept of addressing liability through a chain of contracts between GNSS actors as an approach, in particular, at regional level;

- a model for the future contractual arrangements should embody results of the work done in applying Recommendations 9 and 11;

- the study and development, in the appropriate ICAO forum, of an instrument of international law in the context of the long-term legal and institutional framework for GNSS should be initiated.

* This text was put to an indicative vote during the Third Meeting of LTEP, resulting in fourteen in favour, seven against and one abstention.

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APPENDIX C TO CHAPTER 11

A32-20: DEVELOPMENT AND ELABORATION OF AN APPROPRIATE LONG-TERM LEGAL FRAMEWORK TO GOVERN THE IMPLEMENTATION OF GNSS

Whereas the Global Navigation Satellite System (GNSS), as an important element of the ICAO CNS/ATM systems, is intended to provide safety-critical services for aircraft navigation with worldwide coverage;

Whereas GNSS shall be compatible with international law, including the Chicago Convention, its Annexes and the relevant rules applicable to outer space activities;

Whereas the complex legal aspects of the implementation of CNS/ATM, including GNSS, require further work by ICAO in order to develop and build mutual confidence among States regarding CNS/ATM systems and to support the implementation of CNS/ATM systems by Contracting States;

Whereas the worldwide CNS/ATM systems implementation Conference in Rio de Janeiro in May 1998 recommended that a long-term legal framework for GNSS be elaborated, including the consideration of an international convention, while recognizing that regional developments may contribute to the development of such a legal framework; and

Whereas the recommendations adopted by the worldwide CNS/ATM systems implementation Conference in Rio de Janeiro in May 1998 as well as the recommendations formulated by the Panel of Legal and Technical Experts on GNSS (LTEP) provide important guidance for the development and implementation of a global legal framework for CNS/ATM and in particular GNSS;

The Assembly

1. *Recognizes* the importance of regional initiatives regarding the development of the legal and institutional aspects of GNSS;

2. *Recognizes* the urgent need for the elaboration, both at a regional and global level, of the basic legal principles that should govern the provision of GNSS;

3. *Recognizes* the need for an appropriate long-term legal framework to govern the implementation of GNSS;

4. *Recognizes* the decision of the Council on 10 June 1998 authorizing the Secretary General to establish a Study Group on Legal Aspects of CNS/ATM systems; and

5. *Instructs* the Council and the Secretary General, within their respective competencies, and beginning with a Secretariat Study Group, to:

a) ensure the expeditious follow-up of the recommendations of the worldwide CNS/ATM Systems Implementation Conference, as well as those formulated by the LTEP, especially those concerning institutional issues and questions of liability; and

b) consider the elaboration of an appropriate long-term legal framework to govern the operation of GNSS systems, including consideration of an international Convention for this purpose, and to present proposals for such a framework in time for their consideration by the next ordinary Session of the Assembly.

Chapter 12

ORGANIZATIONAL AND INTERNATIONAL COOPERATIVE ASPECTS

REFERENCES

ICAO's Policies on Charges for Airports and Air Navigation Services (Doc 9082)
Manual on Air Navigation Services Economics (Doc 9161)
Report on Financial and Related Organizational and Managerial Aspects of Global Navigation Satellite System (GNSS) Provision and Operation (Doc 9660)

INTRODUCTION

12.1 Two important characteristics of major CNS/ATM components are the capacity to serve a large number of States, even regions of the world, and the major investments involved in their implementation. This has organizational implications because States will need to cooperate in order to benefit from the efficiency CNS/ATM systems offer. The structure of the international cooperative effort required will differ depending on the implementation option chosen for a specific systems component and the States involved. At the national level, implementation of CNS/ATM systems will be facilitated where financially autonomous bodies have been established to operate air navigation services. Such authorities may also operate airports or be in the form of an autonomous civil aviation authority. Whether at the national or international level, financing of CNS/ATM systems components as well as other air navigation services infrastructure will be enhanced where such autonomous bodies are responsible for infrastructure provision and operation.

ORGANIZATIONAL FORMS AT THE NATIONAL LEVEL

12.2 There are three basic or core forms of organization for providing air navigation services at the national level. These are as follows:

a) a **government department** that is subject to government accounting and treasury rules; its staff are employed under civil service pay and conditions;

b) the **autonomous public sector organization** that is separate from an executive arm of government; however, the government has total ownership of the organization; and

c) the **private sector organization** that is owned by private interests either totally or with the government holding a minority share.

12.3 The decisions made by individual States as to the organizational form at the national level, under which their air navigation services would operate, will depend on the situation in the State concerned, the organization of airspace and whether the provision of services is delegated to other States or delegated under some other organizational form. These decisions will often be strongly influenced by government policy; however, each State would need to take due account of the following factors:

a) the overall framework of government and system of administration followed by the State;

b) the legal and administrative arrangements to ensure that the State's responsibilities to uphold the relevant articles of the Chicago Convention are maintained;

c) forecast industry activity;

d) the sources and cost of funds required to meet related infrastructure investment needs;

e) the requirement of the aviation industry, both international and domestic, to promote increased efficiency of operations by the safe and efficient provision of air navigation services; and

f) the importance of civil aviation to the State's economic and social objectives and the extent to which civil aviation has been developed to meet those needs.

12.4 Whatever organizational form is selected, in accordance with Article 28 of the Chicago Convention, the State is ultimately responsible for the provision and operation of air navigation services. With autonomous entities providing and operating air navigation services, it is recommended (ICAO's Policies on Charges in Doc 9082/6, paragraph 15 refers) that States establish an independent mechanism for the economic regulation of the services. The States should, where necessary, stipulate as a condition for its approval of a new autonomous body or entity, that it observe all relevant obligations of the States specified in the Convention on International Civil Aviation and its Annexes as well as other ICAO policies and practices, such as those contained in ICAO's policies on charges. These include recommendations for States to encourage their air navigation services providers to develop and apply performance parameters in order to improve the quality of services provided and the application of principles of best commercial practice in order to promote transparency, efficiency and cost-effectiveness.

SPECIFIC OPERATIONAL AND TECHNICAL ORGANIZATIONAL ASPECTS

General

12.5 Implementation of CNS/ATM systems will require considerable investment in the area of ATM (e.g. automation and support systems) as well as in communications and navigation infrastructure. The latter involves space segment elements as well as associated ground-based elements (e.g. satellites or satellite transponders, ground earth stations, etc.). The magnitude of the investments involved and the capacity that will be provided are often of such an order that it will not be possible, feasible, nor practical for a State to implement such systems for its sole use.

12.6 When CNS/ATM systems are implemented on a global scale, the need for States to provide and operate conventional communications, navigation and surveillance systems will be significantly reduced. Regional air navigation plans (ANPs) should provide a schedule for the phase-out of facilities made redundant by the provision of CNS/ATM systems services. From an organizational point of view, this will mean that some staff now required to operate conventional systems would become redundant, although some could be redirected towards work associated with the provision of the new CNS/ATM-related services. The extent of the redundancy would also be influenced by the technical solution and implementation option chosen, as described in the paragraphs below. Because of the centralization inherent in satellite operations, redundancies would occur in most States in staff and facilities previously devoted to serving the conventional systems, if the economies of CNS/ATM systems application are to be fully realized.

Aeronautical Mobile Satellite Services (AMSS) — implementation and option selection

12.7 The satellite-based system serving CNS/ATM systems communications needs will require an extensive network of ground-based facilities, including ground earth stations (GES) and associated communications links to air traffic facilities. As there are different means of system access, States will have different implementation options. Depending on requirements and circumstances, a State or a group of States may choose various options. Relevant to the selection of an implementation option and the resulting organizational structure are such economic factors as achievable economies of scale, scope for competition and requirements for economic regulation. It should be stressed, however, that the specific framework a State or group of States selects cannot be established, nor can the appropriate legal instrument covering its establishment be written, until the States concerned have themselves determined which approach best meets their requirements.

12.8 While some States may operate some elements of the ground-based facilities themselves (e.g. GES), access to satellite services will be primarily through service providers that will provide satellite access either directly or by acting as coordinators for satellite operators. From an organizational point of view, however, a State has a number of implementation options to choose from, or it can choose a combination of options. These cover a wide range within which a State can:

a) contract with certified service providers;

b) commission existing multilateral State organizations such as ASECNA, COCESNA and EUROCONTROL to act on its behalf in dealing with service providers;

c) join other States to form a group of States or to form a new international organization which would negotiate for service; and/or

d) use a mechanism within ICAO (e.g. Joint Financing Agreement) to act on behalf of States in dealing with service providers.

12.9 Autonomous civil aviation organizations may prefer to establish direct technical and commercial relationships with satellite service providers where this is possible and feasible.

12.10 Further to the above, the selection of the implementation option a State applies is likely to be strongly influenced by at least two factors, namely, the cost-effectiveness of the alternatives, and the extent to which the State concerned will continue to maintain the control that it may exercise over the provision of services to civil aviation. The latter also includes the extent to which existing facilities and personnel continue to be utilized in the provision of CNS/ATM systems services, as opposed to being made redundant by the implementation option(s) selected.

Global Navigation Satellite System (GNSS)

12.11 The GNSS will initially be composed of a satellite system that provides standard positioning service and system augmentation, which may either have wide area or local area coverage. System augmentation is required for meeting certain performance criteria that may be imposed. Positioning signals are being offered free of charge by the two provider States concerned: at least up to the year 2010 by the Russian Federation (the GLONASS system) and, for the foreseeable future, with six years' advance notice of any change to that policy, by the United States (the GPS system). Both these systems are military systems, which are being made available for civilian use. Until these systems are replaced by (civilian) systems requiring financial commitments from the civil establishment worldwide, the provision, as opposed to the use, of the standard positioning service does not appear to be dependent on organizational issues needing to be addressed by States other than the two provider States.

12.12 Systems augmentation gives rise to somewhat different considerations. For example, wide area augmentation could be provided by the same State(s) or entity that operates a satellite constellation providing global standard positioning service. However, a group of States or a regional organization might also undertake to operate the augmentation satellite service required, either by themselves or by contracting with a commercial or government organization to do so on their behalf. Thus, the same type of options as outlined in 12.8 above apply. In each instance, costs would be incurred that would presumably need to be recovered. From an organizational point of view, such augmentation would in fact be a multinational facility or service to which the guidance material on the provision and operation of multinational facilities and services, which is addressed later in this chapter, could apply, as long as the augmentation is primarily to serve civil aviation. On the other hand, if civil aviation is only going to be a minority user of the augmentation services provided, and the entity will provide augmentation services worldwide, a joint concerted approach through, for example, ICAO, a regional air navigation services providers association, or an international aviation user association, for dealing with the service provider, may be the most appropriate.

12.13 Augmentation with local coverage would most likely not require international involvement provided that the facility meets the specifications and Standards required for it to be listed as an international civil aviation facility. The facility itself could be provided by the national or local government or under contract by a commercial entity.

Air traffic management (ATM)

12.14 With regard to organizational aspects, implementation of CNS/ATM systems has special relevance to ATM. This is because the advanced communications, navigation and surveillance technology offers the possibility to expand the capacity of individual air traffic facilities in many parts of the world and particularly those handling traffic over the high seas. As a result, it will be possible and technically and economically feasible to provide ATM over expanded areas into what could be termed ATM regions, and correspondingly reduce the number of air traffic facilities. However, it should be assumed that the decision made by individual States whether or not to proceed in this manner would not only be taken on technical or economic grounds, but would also depend on other issues in the State concerned that would often be strongly influenced by government policy.

12.15 It should be added that even without an air traffic facility, a State may still need to incur costs associated with providing CNS/ATM systems services as well as other air navigation services for overflying traffic and during the en-route phase of flight for traffic landing on or departing from its territory (e.g. participation in GNSS augmentation schemes, aeronautical fixed service (AFS) links with one or more ACCs, and MET costs). Under such circumstances, such costs together with the costs of closing an air traffic facility would continue to be recoverable by the State(s) concerned. This would call for cooperation or agreement between that State and the entity operating the facility serving the ATM region covering the State concerned. The entity could be an international or regional body, a joint operation by a few States, or another State. The agreement or scheme should call for all costs attributable to the provision of air navigation services to air traffic during the en-route phase of flight, that would be borne by the State which has closed its facility, to be included in the cost base, and recovered through the charges levied, through the facility serving the expanded ATM region. CNS/ATM systems costs attributable to services provided during the approach and/or departure phase of flight would, like the costs of other air navigation services attributable to this phase of operations, be recoverable through approach and aerodrome control charges.

INTERNATIONAL COOPERATION

The multinational facility or service in the context of CNS/ATM systems implementation

General

12.16 A multinational air navigation facility or service has been defined as a facility or service included in an ICAO regional air navigation plan, for the purpose of serving international air navigation in airspace extending beyond the airspace serviced by a single State, in accordance with that regional air navigation plan.

12.17 CNS/ATM systems or individual elements of these systems are probably the most significant multinational facilities or services the aviation community will have access to in the immediate future. This applies to both the service potential of the systems and the costs involved. Where a CNS/ATM systems element is to be provided as a multinational facility or service, the participating States would need to formalize the terms under which that element or multinational facility/service is to be provided in an agreement. A primary aim of the agreement would be to ensure that the costs involved are shared amongst the participating States in a fair and equitable manner. It should be added that any State sharing in the costs of operating a multinational air navigation facility or service can include the relevant costs involved in the cost base for charges, such as air navigation services charges, that it levies.

Implications for States and ICAO technical planning bodies

12.18 Because of the financial and managerial implications involved, the approach by technical planning bodies to the possible implementation of multinational facilities and services may be expected to differ from that applied to facilities or services to be implemented by a single State. Regarding the latter, technical planning bodies essentially focus on the technical aspects of the facilities and services the State concerned must implement to meet its obligations under the respective regional air navigation plan, to serve international civil air traffic within the airspace for which it alone is responsible. Provided these facilities or services meet international Standards, aspects relating to their financing and management remain an internal matter for that State.

12.19 A different approach, however, is required in the case of multinational facilities and services, because the primary reason for their establishment is to enable two or more States to carry out, more efficiently, the services each has accepted responsibility for under the regional plan, and in a more cost-effective manner than each of them could achieve on its own. Consequently, it is to be expected that the States concerned will wish to evaluate, at least in broad terms, the financial aspects of such facilities before agreeing to their incorporation in the regional plan and before committing themselves to utilizing them.

12.20 For this reason, basic financial implications will need to be considered by the technical planning groups at a stage in their deliberations when it is believed that the best or only solution to a problem involves recommending the establishment of a multinational facility or service. To avoid basic financial implications until after these groups have finalized their recommendations could lead to delays if one or more of the States expected to participate in the operation of the multinational facility concerned raises objections, for example, to the financial share it would be expected to pay for. Such delays in implementing technical solutions could compromise safety or efficiency in the area concerned while new solutions acceptable to all the States involved are sought.

Equity aspects

12.21 Equity in the sharing of the costs of a multinational facility or service and in the recovery of the costs through user-charges is important. A multinational facility operated by one State, but providing services used by two or more States, at costs considerably over and above those that would be incurred to solely meet the require-ments of the State operating that facility, may give rise to inequity in two areas if some form of cost sharing is not arranged. First, for the State providing and operating the facility, there is inequity from having to defray capital and running costs in excess of those that the State would otherwise incur to meet its own requirements. Second, where that State would seek to recover its costs through user charges, users within the airspace for which this State is responsible would be asked to pay for costs of services not properly attributable to them. These users would thereby, in effect, be required to subsidize services provided for other traffic by another State. This would be contrary to ICAO policy.

Basic provisions

12.22 The basic provisions that would normally have to be covered in an agreement concerning the establishment and provision of a multinational facility/service are outlined and described in detail in the general guidelines on the Establishment and Provision of a Multinational ICAO EUR Air Navigation Facility/Service, which ICAO has already developed and which forms part of the Introduction to the *Air Navigation Plan — European Region* (Doc 7754) (also reproduced in Appendix 5 of the *Manual on Air Navigation Services Economics Manual* (Doc 9161)). The ICAO Council has decided that such guidelines be developed and included in all other ICAO regional air navigation plans. The guidelines developed by ICAO do not constitute a draft model agreement nor draft model clauses since circumstances related to the planning, implementation and operation of individual multinational facilities/services may vary considerably.

Forms of international cooperation

General

12.23 As has been pointed out earlier, many CNS/ATM systems elements may have to be implemented as multinational facilities and services. The international cooperation may take different forms. In its simplest form there is a coordination and harmonization process initiated as a subregional activity between a limited number of States. There are significant synergies to be created and savings to be made by coordinating the planning, implementation and operation of CNS/ATM systems across borders with neighbouring States. On a larger scale, a more formal machinery may be established as an International Operating Agency, a Joint Charges Collection Agency or an ICAO Joint Financing Arrangement (see Figure I-12-1).

International operating agencies

12.24 An international operating agency is a separate entity assigned the task of providing air navigation services, principally route facilities and services, within a defined area on behalf of two or more sovereign States. The services provided by such an agency are usually in the categories of air traffic services, aeronautical telecommunications, search and rescue (essentially rescue coordinating centres) and aeronautical information services, but can extend to meteorological services for air navigation as well. These agencies are also responsible for the operation of charges collection systems for the services provided. Examples of such agencies are ASECNA (which operates airports as well as air navigation services), COCESNA and EUROCONTROL.

Joint charges collection agencies

12.25 Another effective but less encompassing means for States to benefit from international cooperation in the provision of air navigation services is to participate in the operation of a charges collection agency. This is because States individually operating route facilities and charging for the services rendered will be involved in considerable accounting work and may also encounter collection difficulties where there is a substantial volume of overflying traffic. In such circumstances, a group of adjoining States might benefit significantly from the formation of a joint charges collection agency.

12.26 This agency would collect route air navigation services charges on behalf of all of the participating States, including those that are overflown. Since the majority of aircraft are likely to land in the territory of at least one of the participating States, this would enable most of the route air navigation services charges to be collected without difficulty. The agency would then transfer, to each participating State, the charges revenue collected on its behalf. Added to each charge levied for each participating State would be a small fee or percentage to cover the State's share of the agency's costs. A joint charges collection agency should also benefit the users because the collection costs attributable to each participating State should be lower than that State would otherwise incur itself and need to recover from the users. Considering that route air navigation services charges are an essential source of revenue, it is important that the States themselves, individually or collectively, remain fully in control of the charges collection function. Another factor to be considered is the additional prospect of further economies resulting from the employment of better trained staff and improved procedures.

12.27 The ICAO Council recommends that States or their delegated service providers consider participating in joint charges collection agencies whenever this is advantageous, taking into account the following: the importance of States themselves controlling the collection of their charges; the need for careful study of the terms under which the collection service is to be provided; identification and description of the costs of the services for which they are being charged; and the requirement that any administrative fee be included in the charge.

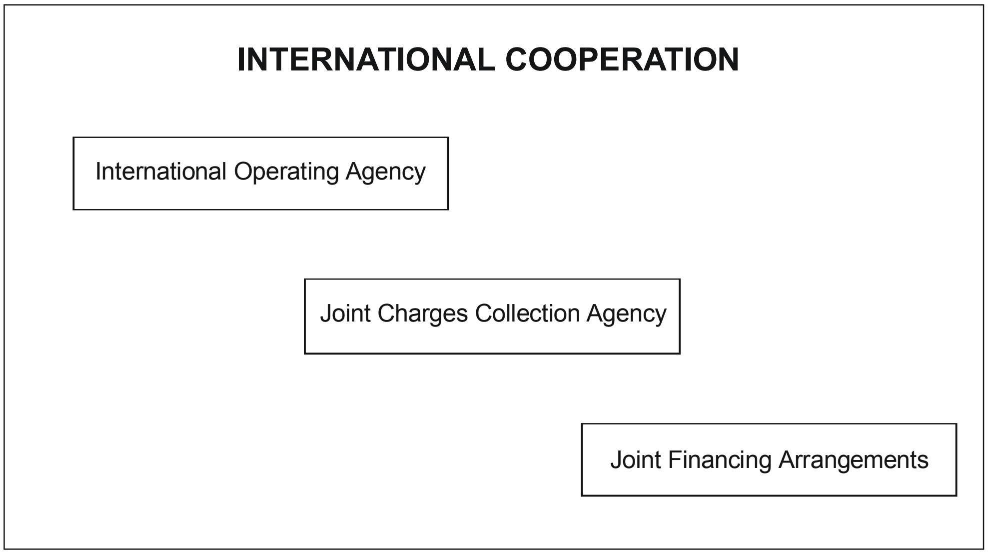

Figure I-12-1. International cooperation

Joint financing arrangements

12.28 Joint financing-type arrangements may lend themselves well to the implementation of a number of CNS/ATM systems elements in situations where it is, for example, very costly for a State to act alone or where an existing regional organization (ASECNA, COCESNA, EUROCONTROL, etc.) does not act on its behalf. Such elements include integrity monitoring and wide area augmentation systems required in connection with GNSS, and could also include GES and the shared use of communications satellite transponders. Agreements for the joint financing of air navigation facilities and services are administered by ICAO on behalf of the contracting governments concerned. The involvement by ICAO in these agreements is provided for under Chapter XV of the Convention on International Civil Aviation (the Chicago Convention) where the basic principles for "joint support" are laid down.

12.29 Under a joint financing-type arrangement, actual provision and operation of the CNS/ATM systems elements concerned could be carried out by one State on behalf of other participating States or contracted to a commercial operator or service provider. Alternatively, a group of States could jointly operate and provide the facilities and services concerned. In the first two instances, ICAO's role in joint financing would be similar to that under the Danish and Icelandic Joint Financing Agreements. Where a group of States would operate the facility jointly, ICAO's role could, however, be expanded, particularly during the implementation phase, to include, *inter alia*, organizing the recruitment of staff, involvement in planning for construction as may be required, and various associated activities. Regardless of who actually provides and operates the facilities or services concerned, in all instances, the participating States under each scheme would exercise full control through a governing joint support-type committee to whom the ICAO joint financing secretariat would report.

12.30 Under the Danish and Icelandic joint financing agreements, the air navigation services are provided by Denmark and Iceland and used by more than eighty States. The arrangements are established in the form of multilateral agreements, which regulate the operation, administration, financing and related support aspects of the air navigation services to be provided under the joint-support scheme. The administration of the agreements is provided by a special section of the ICAO Secretariat which reports to the ICAO Council and its Joint Support Committee. It has its own budget separate from the general ICAO budget. This type of arrangement provides the required neutrality, continuity and aviation-related know-how, while offering the necessary flexibility required for the operation of such international public utilities.

12.31 A related example of a joint financing-type arrangement is the Satellite Distribution System (SADIS) Cost Allocation and Recovery (SCAR) scheme developed by ICAO, which also, upon request of the governments concerned, provides administrative services for the SADIS Cost Recovery Administrative Group. The Group audits the costs of the SADIS service and assesses the annual contribution to be made by each State participating in the scheme. The SADIS service involves the distribution of certain aeronautical meteorological data. The United Kingdom operates the SADIS which is presently financed by the States receiving the service. The SADIS service is received by more than 90 States in Europe, Africa, the Middle East and Western Asia.

ICAO assistance

12.32 Various bodies have pointed out that because of the expertise it possesses and the neutral advice it can provide, ICAO is in a special position to serve States seeking to establish joint ventures to provide air navigation services or to collect charges and, if requested, to administer cost recovery schemes for a multinational facility or service. ICAO could also assist in the preparation and negotiation of loans and could provide routine assessments of economic aspects of air navigation planning and operations. The costs of any such assistance provided by ICAO can be included in the cost basis for charges levied for the facility or service involved. ICAO's role would not be that of an operator on behalf of States but rather of an organizer or coordinator for the States in implementing the joint-venture project and bringing it to full operational status.

Chapter 13

COST-BENEFIT AND ECONOMIC IMPACTS

REFERENCES

Economics of Satellite-based Air Navigation Services — Guidelines for cost/benefit analysis of communications, navigation and surveillance/ air traffic management (CNS/ATM) systems (Circular 257)

GENERAL

13.1 The decision by States on whether and when to enter into the financial commitments necessary to implement CNS/ATM systems in the FIRs for which they have the responsibility to provide ATM should be preceded by appropriate cost-benefit analysis, taking into account the economic impacts on service providers, aircraft operators, passengers and freight consigners. The reasons for cost-benefit analysis were considered briefly in Part I, Chapter 1. User participation in cost-benefit analysis is encouraged. Additionally, each service provider or operator may carry out its own business case or financial evaluation, which will be closely related to the cost-benefit study. Finally, an understanding of the broader economic implications of new systems might be helpful in promoting their implementation.

COST-BENEFIT METHODOLOGY

13.2 A cost-benefit analysis is used to estimate the economic viability of a planned investment project, i.e. the extent to which the total benefit from the investment exceeds its total cost. CNS/ATM systems are complex and consist of a package of investments. Measures of the viability of the *new* investment package (the project case) are based on a comparison with the *existing* systems (the base case). The existing systems are defined to include their normal and expected maintenance and possible development over the planning horizon. The new facilities replace the existing facilities, and as the latter are phased out, their costs can be regarded as benefits from installing the new systems. The most important benefits of CNS/ATM systems are the cost reductions from more efficient flight operations and reduced flight times, which are expected to emerge as CNS/ATM systems are implemented.

13.3 A rigorous approach to developing a measure of the expected economic performance of an investment project is the net present value (NPV) or life-cycle approach, which focuses on the annual flows of costs and benefits (cash flows) related to the project. The costs and benefits in cash flow terms are not distributed evenly over time. Typically, there are large capital expenditures in the early years of a new project followed by many years of benefits, and also of operating and maintenance costs. There could be significant costs during the period of transition from the existing to the new systems, and these must be included in the analysis. The benefits will normally be in the form of cost savings. The net benefit in each year is equal to the sum of all the benefit items minus the sum of all the cost items expected in that year. The NPV (i.e. current year capitalized value) of the stream of net benefits (net cash flows) can be determined by a process of discounting the future cash flows. This process takes into account the effect of the rate of interest on the present value of each future cash flow. (Figure I-13-1 summarizes this approach.)

13.4 Estimation of the future flows of the costs and benefits, and hence the NPV associated with the implementation of satellite-based CNS/ATM systems in an airspace, requires many assumptions about the prices and quantities of communications, navigation and surveillance equipment and services, and about the amount of potential savings in aircraft operating costs. Therefore, there is an element of uncertainty and risk in the NPV results. The financial risks can be appreciated by studying the effects on the NPV estimate resulting from changes in the assumptions. A particularly important assumption is that the transition to CNS/ATM systems by ATM providers and aircraft operators occurs in a coordinated fashion so that net benefits are maximized.

13.5 Comprehensive guidance material to assist States in carrying out cost-benefit studies of the implementation of CNS/ATM systems in their own airspace is available in Circular 257, *Economics of Satellite-based Air Navigation*

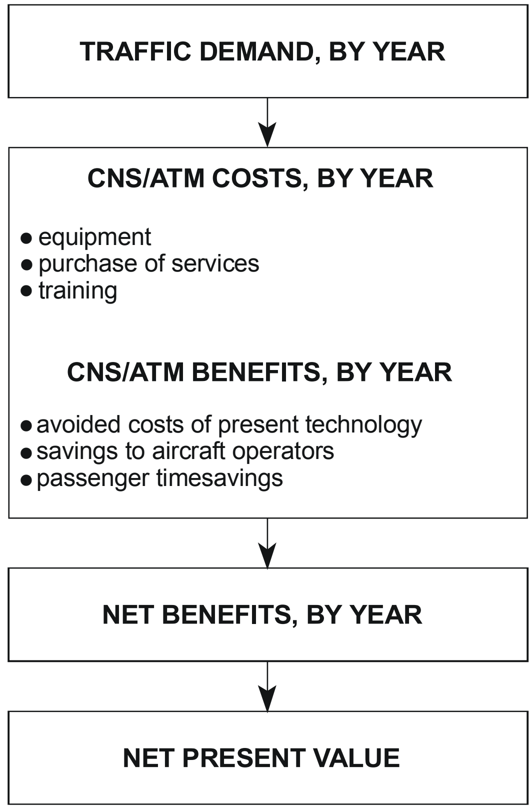

Figure I-13-1. Overview of the net present value (NPV) approach

Services — Guidelines for cost/benefit analysis of communications, navigation and surveillance/air traffic management (CNS/ATM) systems. This circular focuses on the NPV methodology, which is widely recognized and used by financial institutions such as those potentially involved in funding CNS/ATM systems. The methodology is presented using a step-by-step tabular approach, which may be applied manually or through a computer spreadsheet; formatted spreadsheets using Quattro Pro, Lotus or Excel software are available to States from the ICAO Secretariat.

INTERPRETATION OF COST-BENEFIT RESULTS

13.6 The interest rate used for discounting future cash flows should be the minimum rate of return required from investment in the CNS/ATM systems project. If a rate of 7 per cent per annum (real) was used, then any NPV result above zero would imply a forecast of a real rate of return greater than 7 per cent per annum from the investment project. More precisely, the project was expected to earn a real rate of return of 7 per cent per annum plus a surplus equal to the NPV value.

13.7 NPV calculations can be repeated for alternative implementation plans in order to assess which particular plan is the most cost-effective. For example, the NPV of an implementation employing SSR Mode A/C and VDL for surveillance and data communications can be compared with the NPV of an implementation plan with Mode S for both surveillance and data. As another example, the economic consequences of extending or shortening the period during which services are provided by both the present technology and the new technology systems (in parallel) can be assessed in a similar way.

13.8 A cost-benefit analysis can be done for the airspace of a State or group of States. It is recommended that separate cost-benefit analyses be done for the ATM provider or the relevant State authority and for the aircraft operators. Where this is done, it is possible that the State authorities may see only a modest net benefit (NPV) or perhaps even a net financial cost associated with the implementation of CNS/ATM systems. Any such net benefit or net cost experienced by a service provider should be accompanied by adjustments to air navigation charges so that the organization earns a reasonable return on capital invested. It is expected that the cost-benefit analysis for the airlines should produce a large positive NPV, depending on regions and traffic characteristics. Even if some of this net benefit was needed to compensate the service provider, through increased en-route charges, there should normally be an overall surplus.

13.9 The resulting effect on the airlines' net financial benefit attributable to implementation of CNS/ATM systems in a region or State must be examined. Figure I-13-2 illustrates the three options for using these benefits: by compensating the service providers, if necessary, improving airlines' financial performance or reducing fares and rates.

13.10 Competitive market forces should ensure that the airlines' net benefit, which remains after compensating the service providers, will be passed on by the airlines to the passengers, both local residents and visitors, and freight shippers, including exporters and importers, in the form of lower fares and rates, in real terms. This represents the main contribution of CNS/ATM systems to the economy of States. In due course, lower fares should increase the demand for air travel and tourism, and lower freight rates should improve the cost structure of companies and increase trade. The benefits associated with this extra demand are expected to be much smaller than the benefits received by the existing air traffic and are more difficult to measure.

RISKS FOR STATES

13.11 There could be a financial risk for some States associated with the diversion from their airspace of international overflight traffic as a result of the regional implementation of CNS/ATM systems. From a regional perspective, a redistribution of traffic flows associated with CNS/ATM systems should contribute to the overall economic benefit of the new systems. However, from the perspective of a single State, the impact of the redistribution could be quite complex, with either positive or negative consequences. For example, if the geographic pattern of the traffic were such that the realignment of flight paths reduced the traffic in the State's airspace, the State would have access to less revenue. The loss of revenue might be even greater if the State did not convert to the new systems.

13.12 The prospect of new flight patterns emphasizes the importance of international cooperation, not only for implementing the most efficient routes, but also for achieving an acceptable distribution of benefits and for reducing the financial risks faced by individual States. Cost-benefit studies for regional State groupings have an important role in the regional planning of CNS/ATM systems. The net economic impact may be more accurately measured at the regional or subregional level, since it is at this level, rather than at the State level, that some of the costs will be incurred, and the benefits received. Because of the long time frame of the studies, it may also be necessary to update the validation, for example after five years of operation of the new systems.

Business case evaluation

13.13 The development of a business case for the implementation of CNS/ATM systems by a service provider or an operator involves taking the financial cost-benefit analysis a step further. In particular, changes in revenues resulting from changes in the price of the product sold must be taken into account. It is generally expected that CNS/ATM systems will facilitate reduced operating costs and a lower price for the service provided. From the point of view of a specific organization, assessment of the net financial impact, in present value terms, must include not only the implementation cost and operating cost savings, which are included in the cost-benefit analysis, but also consequent changes in revenues.

13.14 For a service provider, a business case evaluation must include the impact on revenues of changes in route charges associated with the implementation of CNS/ATM systems. Assuming that the ATM service provider is an autonomous organization operating on a commercial basis and is currently covering its costs with the present technology systems, the basic issue is for the service provider to be satisfied that the changes in revenues expected from the planned changes to en-route charges will match the net change in costs, measured by the cost-benefit analysis. However, if the relationship between costs and revenues is not being monitored (e.g. if costs are met from the government budget and revenues are treated independently as general government revenues), then the ATM services are not being provided on a commercial basis. Even in these circumstances it is recommended that a business case evaluation be conducted to assess the financial impact of the new systems on the service provider.

13.15 For an airline, a business case evaluation would include, among other factors, assumptions about the impact on its costs of expected changes in route charges and the impact on revenues of changes in airline fares and rates, where these changes are associated with the implementation of CNS/ATM systems. These impacts are in addition to the direct investment costs and operating cost savings

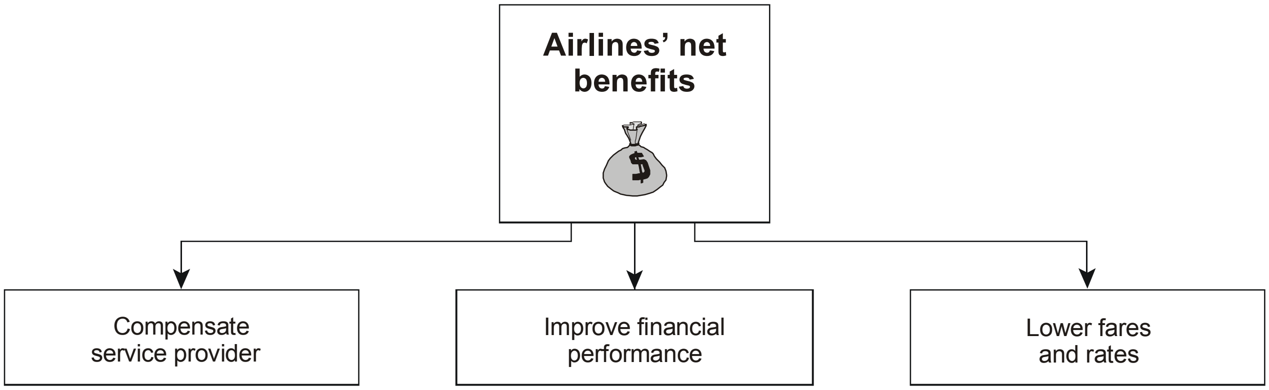

Figure I-13-2. Distribution of airlines' net benefits

attributable to the new systems and identified in the cost-benefit analysis described above. The impact of route charges will depend on the outcome of the policies and evaluations of the service providers. Assumptions about fares and rates will reflect competitive pressures in air travel and freight markets.

Other economic effects of CNS/ATM systems implementation

13.16 States may be interested in the broader economic and social impact of CNS/ATM systems as well as the financial viability of the new systems. For example, implementation of the new systems should produce passenger timesavings, improve safety, produce environmental benefits and may also lead to some industry restructuring and changes in skills required.

13.17 CNS improvements, which produce benefits for ATM such as more direct flight paths and less delay from airspace congestion, will reduce the passenger travel time for a given journey. If passengers value these timesavings, they represent an additional benefit. The evaluation of this benefit is discussed in Circular 257.

13.18 CNS/ATM systems are expected to bring environmental benefits because of reductions of nitrous oxide and carbon emissions through more direct routing of aircraft. These benefits will accrue to the global community in general and are not limited to participants in the air transport industry. Recognition of these benefits provides a reason for subsidizing investment in CNS/ATM systems. The increase in automation of ATM, the withdrawal of some ground-based navigation aids, and the possible relocation of some ATM facilities to fewer centralized locations should result in labour productivity improvements, and hence reductions in unit costs, over the long term. The labour released by this process should, in most regions, be absorbed by the requirement to service expanded traffic volumes generated by general economic growth. However, there may be situations where some redeployment of staff to other economic sectors is necessary, with further economic and social consequences.

13.19 The reduced costs and lower price of air transport made possible by CNS/ATM systems, and the resulting increased air traffic demand, could increase the viability of investment in activities closely related to air transport, not only accommodation and tourism, but also those manufacturing and agricultural industries which ship materials and products by air. These indirect benefits are part of a dynamic process of economic growth and should not be attributed *entirely* to CNS/ATM systems. They will only be fully exploited provided the complementary investment in the associated industries is undertaken. The various economic effects are highlighted in Figure I-13-3.

13.20 An understanding of the contribution of air transport to general economic activity can increase the political commitment to the process of transition to CNS/ATM systems. National accounting and industry data and employment surveys may be used to determine the share of air transport in total economic activity and its importance as an employer. The input/output tables of a State's national accounts can illustrate the interrelationships among the various elements of the air transport industry and other industries and economic sectors. Other industries purchase air transport services or supply products and services to the air transport industry. From a national or regional economic planning perspective, it is especially important to appreciate the role of air transport in generating employment and incomes and in supporting other non-aviation economic activities. This will put into perspective the value of supporting and investing in state-of-the-art national and regional air transport facilities.

ECONOMIC EFFECTS

- Financial benefits and lower fares and rates
- Improved safety
- Passenger timesavings
- Environmental benefits
- Transfer of high-tech skills
- Productivity improvements and industry restructuring
- Higher traffic and stimulation of related industries

Figure I-13-3. Summary of economic effects of CNS/ATM

Chapter 14

FINANCIAL ASPECTS

REFERENCES

ICAO's Policies on Charges for Airports and Air Navigation Services (Doc 9082)
Manual on Air Navigation Services Economics (Doc 9161)
Report on Financial and Related Organizational and Managerial Aspects of Global Navigation Satellite System (GNSS) Provision and Operation (Doc 9660)
Manual on Air Traffic Forecasting (Doc 8991)

INTRODUCTION

14.1 Financing CNS/ATM systems elements, in particular at the national level, would normally be approached in a manner similar to that applied to conventional air navigation systems. However, a characteristic of most CNS/ATM systems elements that differentiates these systems from most conventional air navigation systems is their multinational dimension. Consequently, and because of the magnitude of the investments involved, financing of basic systems elements may, in many cases, need to be a joint venture by the States involved at the regional or global level.

COST-RECOVERY

ICAO policy

14.2 Whatever approach is taken by a State or group of States collectively to provide CNS/ATM systems services within the airspace for which responsibility has been assumed, the resultant cost-recovery through charges must be in conformity with basic ICAO airport and air navigation services cost-recovery policy. This policy is contained in Article 15 of the Convention on International Civil Aviation (Chicago Convention) and is supplemented by *ICAO's Policies on Charges for Airports and Air Navigation Services** (Doc 9082). The implementation of CNS/ATM systems should not require any basic changes to that policy.

14.3 The Statement of ICAO Policy on CNS/ATM Systems Implementation and Operation, approved by the ICAO Council in March 1994, addresses cost-recovery as follows:

> "In order to achieve a reasonable cost allocation between all users, any recovery of costs incurred in the provision of CNS/ATM services shall be in accordance with Article 15 of the Convention and shall be based on the principles set forth in the *Statements by the Council to Contracting States on Charges for Airports and Air Navigation Services*** (Doc 9082), including the principle that it shall neither inhibit nor discourage the use of the satellite-based safety services. Cooperation among States in their cost-recovery efforts is strongly recommended."

14.4 In ICAO's policies set out in Doc 9082, the following four general principles should particularly be noted with regard to CNS/ATM systems:

a) in paragraph 36, ". . . as a general principle, where air navigation services are provided for international use, the providers may require the users to pay their share of the related costs; at the same time, international civil aviation should not be asked to meet costs that are not properly allocable to it . . .";

b) paragraph 38 i), "The cost to be shared is the full cost of providing the air navigation services, including appropriate amounts for cost of capital

* Replacing *Statements by the Council to Contracting States on Charges for Airports and Air Navigation Services.*
** Since retitled *ICAO's Policies on Charges for Airports and Air Navigation Services (Doc 9082/6).*

and depreciation of assets, as well as the costs of maintenance, operation, management and administration.";

c) in paragraph 38 ii), "The costs to be taken into account should be those assessed in relation to the facilities and services, including satellite services, provided for and implemented under the ICAO Regional Air Navigation Plan(s) . . ."; and

d) in paragraph 47, ". . . the providers of air navigation services for international use may require all users to pay their share of the cost of providing them regardless of whether or not the utilization takes place over the territory of the provider State."

14.5 Particular attention also needs to be given to the following principle in paragraph 41 iii) of Doc 9082:

> "Charges should be determined on the basis of sound accounting principles and may reflect, as required, other economic principles, provided that these are in conformity with Article 15 of the Convention on International Civil Aviation and other principles in this document."

The application of economic principles to setting charges which are consistent with ICAO's policy should emphasize the need to recover costs in an efficient and equitable manner from the users of air navigation services. Within an economic context, charges should be set to recover costs, provide a reasonable return on investment where appropriate and provide additional capacity when justified.

14.6 In a situation where system operation takes place outside the service provider State, that State nevertheless must approve the use of the service within the airspace for which it has accepted responsibility. It also must ensure and stipulate that the service meets ICAO requirements. Furthermore, if services are charged for, the charging practices must be established in accordance with ICAO recommended cost-recovery policy and practices.

14.7 In a recent review of ICAO cost recovery policy, pre-funding of projects was given extensive consideration and the following policy guidance was added in paragraph 42 of Doc 9082:

> ". . . notwithstanding the principles of cost-relatedness for charges and of the protection of users from being charged for facilities that do not exist or are not provided (currently or in the future) that, after having allowed for possible contributions from non-aeronautical revenues, pre-funding of projects may be accepted in specific circumstances where this is the most appropriate means of financing long-term, large-scale investment, provided that strict safeguards are in place, including the following:
>
> i) Effective and transparent economic regulation of user charges and the related provision of services, including performance auditing and "bench-marking" (comparison of productivity criteria against other similar enterprises).
>
> ii) Comprehensive and transparent accounting, with assurances that all aviation user charges are, and will remain, earmarked for civil aviation services or projects.
>
> iii) Advance, transparent and substantive consultation by providers and, to the greatest extent possible, agreement with users regarding significant projects.
>
> iv) Application for a limited period of time, with users benefitting from lower charges and from smoother transition in changes to charges than would otherwise have been the case once new facilities or infrastructure are in place."

Cost determination

Relevance of ICAO regional air navigation plans
in the context of CNS/ATM cost-recovery

14.8 As stated above, charges for CNS/ATM systems services should not be imposed unless these services are actually being provided according to the regional ANPs concerned. Consequently, it is important that regional plans be promptly amended to incorporate the relevant CNS/ATM system element(s) once the States involved have agreed that the element(s) should form part of the plan or plans concerned.

14.9 Moreover, the regional ANPs should provide a schedule for the phase-out of facilities made redundant by the provision of CNS/ATM systems services. This is also of major importance because significant financial benefits from CNS/ATM systems implementation will not be realized if the facilities and services made redundant, continue to be listed in the regional plans and charged for.

14.10 As CNS/ATM systems components are implemented, States should add the associated costs to their cost base for air navigation services charges. States sharing the costs of a multinational air navigation facility or service may include the costs involved in its cost base for charges. CNS/ATM system trials and major research and development work may be included as part of the capital investment, the subsequent annual depreciation of which could then be included in the cost base for air navigation services charges.

Determining CNS/ATM systems costs

14.11 The CNS/ATM systems services costs attributable to en-route utilization could be included, together with other air navigation services costs allocable to en-route utilization, in the cost basis for, and recovered through, route air navigation services charges levied by the State concerned. However, as noted in Chapter 12, 12.16, implementation of CNS/ATM systems offers the cost saving potential of merging many FIRs and correspondingly reducing the number of ATC facilities. Nevertheless, even without an en-route ATC facility such as an ACC, a State would still need to incur costs associated with providing CNS/ATM systems services as well as other air navigation services to traffic during the en-route phase of flight, e.g. costs associated with participation in and/or provision of GNSS augmentation, provision of AFS links with one or more ATC facilities, MET services, etc. Recovery of these costs would require cooperation or agreement between the State concerned and the entity operating the facility serving traffic in the expanded ATM area wherein the State concerned would be located. The purpose of such an approach would be for route air navigation services costs to be included as an identifiable element in the cost basis for, and recovered through, the charges levied by the facility serving the expanded ATM area. The charges share represented by these costs would then be transferred to the State upon payment by the users.

14.12 The costs of air navigation services provided during the approach and aerodrome control phase of aircraft operations should be identified separately and could either be included in any approach and aerodrome control charges that might be levied on traffic at the airports concerned or, alternatively, could be included in approach and/or aerodrome control costs that would be charged by the ATM provider to any of these airports. In the latter instance, each airport could then include those costs, together with other air navigation services costs, in the cost basis, and recover them through landing or similar charges.

14.13 From an organizational viewpoint, it is important, with regard to cost-recovery, that where air navigation services costs are to be recovered, the State concerned should assign, to one entity, the responsibility for ensuring that the costs attributable to the provision of air navigation services by the different entities in the State are included in the cost basis for any cost-recovery programme or mechanism.

Allocation of CNS/ATM systems (GNSS) costs to other than civil aviation users

14.14 Civil aviation users constitute a minor share of navigation satellite users. More important than the magnitude of civil aviation's usage in relative terms is that the users should not pay for more than their fair share of the costs of GNSS provision. Allocation of costs for systems augmentation or other costs of GNSS service provision attributable to users other than civil aviation, as well as civil aviation, should therefore precede any cost-recovery from civil aviation.

Allocation of CNS/ATM systems costs attributable to civil aviation among user States

14.15 Costs, in the form of payments made by a State to a service provider offering CNS/ATM systems services to several States, will need to be allocated amongst the different CNS/ATM systems user States involved. That, in turn, will require an agreement between the parties concerned as to how such an allocation should proceed. Assuming a uniform level of service, such allocation could be based on either distance flown or the number of flights in the airspace for which each State has accepted responsibility. Both are viable options. Distance flown would offer more precision while using number of flights as the basis would be simpler to administer.

Allocation at the State level of CNS/ATM systems costs attributable to civil aviation

14.16 Once the costs attributable to civil aviation have been determined and cost-recovery from users is to be pursued, consideration will need to be given to the allocation of these costs between en-route, approach and aerodrome control utilization. This in turn will determine the extent to which route air navigation services charges, as opposed to approach and aerodrome control charges, will be affected. To ignore this issue when users are to be charged directly would distort the principle of equity in charging, since overflying traffic could be subsidizing landing traffic or vice versa, depending on the accuracy of the cost allocation.

Cost-recovery during development and implementation

14.17 One particular issue that needs to be addressed in the implementation of CNS/ATM systems is the treatment of costs and cost-recovery during the three stages of systems implementation, i.e. development, transition and CNS/ATM systems as the only systems. Paragraph 3.8 of the *Report on Financial and Related Organizational and Managerial Aspects of Global Navigation Satellite System (GNSS) Provision and Operation* (Doc 9660) addresses this particular issue in the specific context of GNSS.

14.18 The implementation of CNS/ATM systems elements will, in many cases, lead to the retirement of existing ground-based facilities before the end of their economic life. In such circumstances, the balance of the undepreciated portion of the facilities concerned could be included in the cost basis for charges. The same procedure could apply to such costs that may be incurred because of premature retirement or training of personnel made redundant by the implementation of the new systems. Such costs, however, should be limited to termination settlements, costs attributable to early retirement and costs of retraining and/or relocation. These costs could be capitalized and thereafter written off gradually, with the portion written off each year being included in the cost basis for air navigation service charges. These factors would need to be taken into account in any related cost-benefit analysis or business case study.

Compensation where revenues from redundant facilities exceed costs

14.19 As a result of CNS/ATM systems implementation, some States may experience a net loss in revenue. Compensation for loss of what is in essence profits should be viewed with extreme caution, considering that there are the broader socio-economic benefits generated by opening up new or improved air services. Moreover, such compensation, if included in the cost basis for charges, could in fact be considered a royalty payment, which would be contrary to the intent expressed in Article 15 of the Chicago Convention.

Consultation with users

14.20 Particular attention should be drawn to Doc 9082, paragraphs 49 to 51, and the emphasis placed on consultation with users regarding increased or new air navigation services charges; and also on users being consulted as early as possible when major air navigation services are being planned. This would call for such consultations to be carried out when plans are being developed for the implementation of CNS/ATM systems elements, whether at the global, regional or national level.

FINANCING

General

14.21 The basic steps of financing include air traffic forecasts, a financial and economic analysis, a financing plan and sources of financing (see Figure I-14-1).

14.22 Direct financing of many basic components may not involve aviation at all, particularly where aviation is only a relatively minor, even if important, user of a particular system, e.g. satellite navigation. In such situations, financing may be arranged by the system operator with aeronautical users paying for access through leases or charges, which would include an element to recover the costs of financing and repayment of capital.

Air traffic forecasts

14.23 Sound traffic forecasts are essential to any air navigation services infrastructure development project and its financing. The main purpose of such forecasts is to identify traffic developments and to establish the associated capacity requirements of the air navigation facility or service involved. These forecasts are also important for carrying out financial and economic analyses and for preparing revenue estimates from charges on air traffic. For guidance on the preparation of traffic forecasts, reference is made to the *Manual on Air Traffic Forecasting* (Doc 8991).

Financial and economic analysis

14.24 Every major investment decision taken by a service provider should be supported by analyses to demonstrate costs and benefits to service providers, users and, as appropriate, the wider community. Such analyses are important when choosing between options for the implementation of CNS/ATM systems and when seeking government or private financing. Three types of analyses may be of interest:

1) **cost-benefit analysis** to demonstrate financial viability and to identify the investment option that best

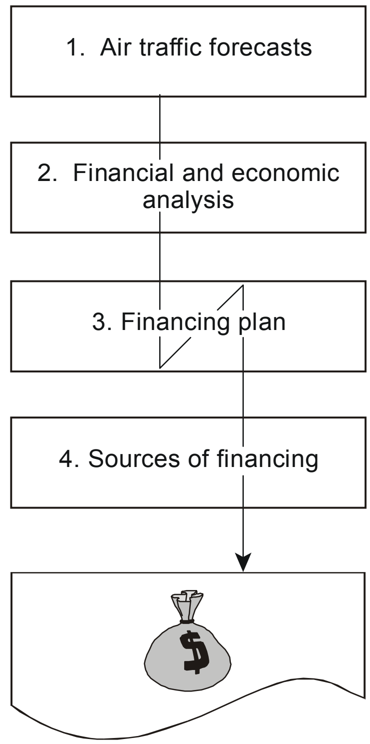

Figure I-14-1. The basic steps of financing

conforms with the economic goal of maximizing net benefits; and/or

2) **business case study (financial evaluation)** which deals with the direct costs, revenues and sources of funds and focuses on financial accounts and cash flows to demonstrate to a service provider of capital funds that loan obligations can be served;

3) **economic impact study** to assess the contribution of air navigation services to the economy.

Note.— Financial and economic analysis are discussed in more detail in Part I, Chapter 13.

Financing plan

14.25 The purpose of the financing plan is to provide basic information as follows:

a) estimates of the element costs (labour, materials, equipment, etc.) of each distinct part of the overall project;

b) the funds required to make disbursements at various stages in the project's progress;

c) the currencies in which payments are to be made; and

d) the sources from which the funds are to be forthcoming, whether from:

1) sources generated by the entity providing air navigation services from its operations, which would primarily include user charges, and possibly retained earnings, but could in some circumstances also include contractual payments; or

2) other sources, including information on the applicable conditions, i.e. interest rate, repayment period, etc.

14.26 Also to be emphasized is the importance of the availability of data showing the financial situation of the air navigation services provider over recent years, as well as anticipated developments over the period of debt repayment. Of particular relevance is the recording of revenues

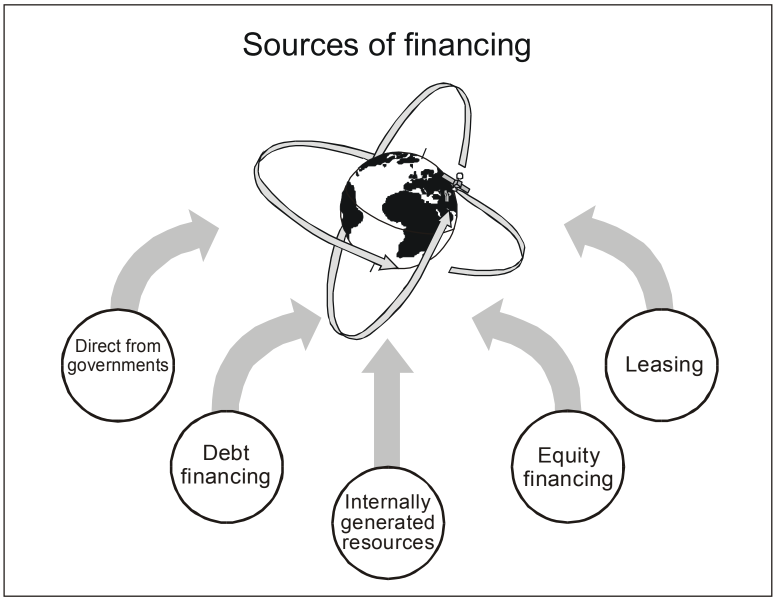

Figure I-14-2. Sources of financing

and expenses by major item. Estimates regarding future financial developments would emanate from budgets and longer-term financial plans. In the absence of such financial data, it would be much more difficult to decide whether or not the loan or financing sought should be granted and, if so, what terms should be offered.

Sources of financing

General

14.27 A survey of potential sources of funds and which of them to approach should be done as early as possible in the planning process. Potential sources of funds will vary considerably from project to project and State to State. The sources to be approached should be studied and decided upon individually for each project and could be grouped as follows: direct contributions from government(s); loans or debt financing; internally generated resources; equity financing; and leasing (see Figure I-14-2).

Direct contributions from governments

14.28 The extent to which direct contributions will be required from the government depends on a number of factors. Chief among these is the organizational form under which CNS/ATM systems services will be provided, i.e. will the government be directly involved, either alone, or in a joint effort with other governments, or will it primarily involve a commercial corporation? Another factor is the type of CNS/ATM systems component involved, e.g. is funding being required for satellite elements or "national" ground-based facilities? Yet another factor is whether the traffic volume within the airspace concerned is sufficient to support the CNS/ATM systems component in financial terms, including servicing debt. If such traffic is not sufficient, as in a situation where, for example, a local augmentation unit would service one or more airports with very limited traffic, direct contributions from the government may be the only realistic alternative.

14.29 For most States, particularly developing States, the foreign sources of financing are principally government-operated. Such foreign financing may be available from foreign governments in the form of loans negotiated directly with the government of the recipient country, or may otherwise be facilitated by particular agencies of government, which have been established for the primary purpose of promoting the nation's export trade. Of particular importance among the possible sources of foreign financing available to developing States are the international banks and funds that have been established to assist in the financing and execution of projects promoting national economic development.

14.30 Project costs payable in foreign funds constitute a demand on the State's reserves of foreign exchange and as such their financing will usually have to be arranged through or with the approval of the appropriate government authorities. Nevertheless, foreign sources should always be explored as a matter of course, since financing may be available from them on more favourable terms than those obtainable from domestic institutions (e.g. lower interest rate, repayment over a longer period, etc.). However, there are also some risks involved in foreign exchange, such as currency fluctuations.

Debt financing

14.31 The feasibility of debt financing will depend on whether the traffic to be served by the CNS/ATM systems component to be financed is of sufficient volume and strength to service the debt, including interest and repayment of capital. Where an international agency or corporate-type entity would be providing basic CNS/ATM systems services, its costs of financing could be reduced if the States for which the basic services are being provided were to guarantee the servicing and repayment of the loans concerned. This in turn should reduce the costs to be recovered from these user States.

Internally generated resources

14.32 Depreciation and retained profits from the operation of air navigation services may become a supplementary source of financing for CNS/ATM systems facilities. However, with regard to profits, an important qualification that needs to be recalled is the principle outlined in Doc 9082, paragraph 38:

> "Air navigation services may produce sufficient revenues to exceed all direct and indirect operating costs and so provide for a return on assets (before tax and cost of capital) to contribute towards necessary capital improvements."

Reference should also be made to the text on pre-funding of projects in 14.7 above.

Equity financing

14.33 Equity financing may be a viable alternative in some instances. For example, if a CNS/ATM systems component's services were acquired under contract from a commercial service provider, that operator could finance the investment required partially or completely through increased equity.

Leasing

14.34 Leasing rather than outright ownership could become an important alternative in CNS/ATM systems component provision. This could apply, for example, with regard to GNSS integrity monitoring and wide-area augmentation systems, where access may be effected in a less time- and capital-consuming manner than if the State(s) concerned were to operate these facilities itself (themselves). The possibility could also be explored of applying leasing to local area augmentation units, possibly through the establishment of leasing companies, which would operate in a manner similar to those purchasing and leasing out, for example, computer systems, communications systems and/or aircraft under long-term leases.

Chapter 15

ASSISTANCE REQUIREMENTS AND TECHNICAL COOPERATION

REFERENCES

ICAO Strategic Action Plan
Statement of ICAO Policy on CNS/ATM Systems Implementation and Operation, ICAO Council, 1994
Criteria Governing the Provision of Technical Co-operation, ICAO Council 1984

INTRODUCTION

15.1 Planning and implementation of CNS/ATM systems requires cooperation among all partners that have a stake in its successful implementation. Assistance requirements of developing States in particular, need to be addressed. Technical and financial cooperation of the aviation and development financing communities will be required worldwide with the coordination of ICAO to ensure harmony and safety.

15.2 ICAO has established the ICAO Objectives Implementation Mechanism, *inter alia,* to foster early and harmonious implementation of CNS/ATM systems and to create an avenue for the planning and implementation of CNS/ATM systems-related projects, for the ultimate benefit of the recipient States and the users of the system.

ASSISTANCE REQUIREMENTS OF DEVELOPING ICAO CONTRACTING STATES FOR CNS/ATM PLANNING AND IMPLEMENTATION

Summary of ICAO surveys

15.3 On behalf of the CNS/ATM Systems Implementation Task Force (CASITAF), which was comprised of representatives from a wide range of States, international organizations, industry and observers, convened by ICAO in 1994, the Technical Co-operation Bureau (TCB) of ICAO conducted an initial survey of States' requirements for assistance in CNS/ATM planning and implementation, through a questionnaire involving seven ICAO Regional Offices. The replies to that questionnaire indicated a substantial need for assistance and a preference for this assistance to be provided through ICAO. Having considered the results of the survey, and to ensure harmonization of implementation and early benefits to users, CASITAF recommended that where assistance was required it should be provided through ICAO.

15.4 The results of this survey were presented to the ALLPIRG/Advisory Group, which is comprised of representatives of the planning and implementation regional groups (PIRGs), ICAO regional offices, international organizations, industry and observers, at a meeting convened by ICAO in April 1997. Another survey was carried out by ICAO in the first half of 1997 to update and further define the assistance requirements of the developing ICAO Contracting States for CNS/ATM systems planning and implementation. A breakdown of the results of the survey into areas of assistance requirements and sources of assistance is provided in Appendices A and B to this chapter, respectively.

15.5 The results of the 1994 and 1997 ICAO surveys and experience gained through initial ICAO technical cooperation projects on the subject (described below) confirm that, while some States will be in a position to develop their national CNS/ATM systems plan and implement it using their own resources, the majority of States require external assistance. The surveys demonstrated that developing States mainly require assistance with:

— needs assessments and project development;

— donor mobilization and financing arrangements;

— familiarization/specialized seminars and workshops;

— transition planning including cost-benefit and cost-recovery analyses;

— systems planning, specification, systems procurement, installation, commissioning; and

— human resource planning and development.

15.6 The 1997 survey in particular provided an overview of the needs of developing States in the various PIRGs, listed by areas of major assistance requirements (see Appendix A to this chapter). Out of a total of 79 responses received from developing States, 68 indicated that they were in need of external assistance for CNS/ATM systems planning and implementation in one or more areas listed above. Furthermore, about 80 percent of the responses stated a need for external assistance across the whole spectrum, i.e. from a formal needs assessment survey, through implementation planning, including cost-benefit analysis and systems procurement, to human resources planning and development. Satisfying this need of developing States, not only with regard to transfer of know-how but also for external financing, is a major task for the international community. This task requires urgent attention if globally harmonized implementation of CNS/ATM systems is to be achieved and early benefits are to be realized by users.

Sources of assistance and funding

15.7 The results of the 1997 survey also demonstrated the desire of the majority of developing States to obtain external technical assistance from ICAO for CNS/ATM systems planning and implementation (see Appendix B to this chapter). Out of the 68 responses received from developing and least developed States, 83 per cent of developing States and 97 per cent of least developed States replied that they rely on ICAO to provide external assistance, while 49 per cent of developing States and 48 per cent of least developed States also indicated the need for assistance in specific areas, from other external sources.

15.8 To meet the needs of developing States for external assistance and funding through or from ICAO, funding will have to be made available by the international development financing community.

15.9 It is anticipated that bilateral assistance, whether through grants or loan arrangements, will be increasingly made available to developing States requiring major upgrading of civil aviation equipment. Transfer of know-how through specialized expertise in CNS/ATM systems planning and, in particular, human resource development, will require the involvement of the aviation industry and the development and financing communities, particularly multilateral donors. Whereas interregional planning efforts, including accompanying training, would be more suitable for financial support from global development financing partners, such as certain Bretton Woods organizations; international organizations and associations; industry and service providers as representative partners and regional development banks, these may be joined by subregional associations and States for regional, subregional and national planning and implementation of CNS/ATM systems.

ICAO OBJECTIVES IMPLEMENTATION MECHANISM

15.10 The following paragraphs describe the ICAO mechanism established to assist, *inter alia*, in coordinating the provision of assistance in CNS/ATM systems planning and implementation, in which the above-mentioned development partners, as well as States themselves, may find a suitable channel to provide the necessary support.

Establishment

15.11 The ICAO Objectives Implementation Mechanism was established by the ICAO Assembly in 1995. The Assembly endorsed a new policy on ICAO technical cooperation, which included the establishment of a funding mechanism, as well as the objectives of the new policy emphasizing global implementation of SARPs and ANPs, including, in particular, CNS/ATM. The Assembly encouraged Contracting States "to make use of the Technical Co-operation Programme of ICAO and to contribute to this new funding mechanism, aimed at consolidating all other funding arrangements". The first meeting of the ALLPIRG/Advisory Group, held in April 1997, concluded that ALLPIRG members, in order to ensure timely and coordinated implementation of CNS/ATM systems, should support ICAO and States in mobilizing funds for the ICAO Objectives Implementation Mechanism of the ICAO Technical Co-operation Programme in line with Assembly resolutions. The Technical Co-operation Programme is described in 15.16 to 15.20.

Objectives

15.12 The aims of the ICAO Objectives Implementation Mechanism are to provide additional resources to ICAO for following up on ICAO's Regular Programme activities; resources which could be applied to technical cooperation projects identified as required to support the implementation of SARPs and the facilities and services listed in the ANPs. The mechanism is strategically linked to ICAO's plans for the implementation of CNS/ATM systems.

It stimulates ICAO's action for initiating projects required for the development of international civil aviation.

15.13 The mechanism gives priority and support to technical cooperation activities in the field of SARPs and ANPs implementation, CNS/ATM, safety oversight, aviation security, civil aviation master planning, restructuring of civil aviation departments/authorities and human resource development.

Contributions to the mechanism

15.14 The ICAO Objectives Implementation Mechanism includes a variety of funding modalities to suit particular donors' needs and provides a framework for flexible arrangements for the implementation of projects. Donations are also welcome in the form of voluntary contributions in kind, such as scholarships, fellowships, training equipment and funds for training, from States and other public or private sources.

15.15 Funding and operation of the mechanism has been established, separately or in combination with each other, in accordance with the following methods:

a) **General fund**. States or donors deposit funds in a special account established for the mechanism. These funds are used exclusively for the implementation of technical cooperation projects approved by ICAO. The funds are not to be tied to projects for any special area or purpose nor are they to be used for the purchase of equipment in the donor country or employment of its nationals, etc.

b) **Specific ICAO project**. States or donors indicate their willingness to participate in the mechanism and give an indication of the amount they expect to donate for the year. Periodically during the year, ICAO circulates descriptions of projects requiring financing and States or donors indicate their willingness to finance all or part of a particular project. On advice from ICAO of the intent to proceed with a project, the funds are deposited in the account established for that project.

c) **Specific State project**. States or donors advise ICAO of their desire to see a particular improvement or development implemented and their willingness to finance the project under the mechanism for technical cooperation. ICAO costs the project and submits a preliminary budget to the States or donors. On approval of the preliminary budget, a full project document is developed for signature by the recipient State, the donor and ICAO. The necessary funds are then deposited with ICAO in an account established for that project.

d) **General but identified issue.** A variation of the method outlined in c) is for a State or donor to make funds available for a particular issue, but to leave it to ICAO to decide how the funds are to be spent. For example, funds may be used for fellowships or for advancing some specific technical matter, such as CNS/ATM.

ICAO TECHNICAL COOPERATION IN CNS/ATM IMPLEMENTATION

Mandate, objectives and role

15.16 ICAO offers technical cooperation in the civil aviation field through its Technical Co-operation Bureau (TCB), which was created in 1952. TCB carries out projects funded by developing States themselves or by various bilateral and multilateral funding institutions, including UNDP.

15.17 The Criteria Governing the Provision of Technical Co-operation, approved by the ICAO Council in 1984, define the objectives of ICAO technical cooperation as follows:

> "ICAO will cooperate with Governments in providing assistance to civil aviation development in any sector, international or domestic, when such development will promote the economic and/or social growth of the country concerned, or will enhance the safety and efficiency of civil aviation and implementation of the Regional Air Navigation Plan."

15.18 More specifically, with regard to CNS/ATM, in 1994 the ICAO Council "recognized, in the interest of globally coordinated, harmonious implementation and early realization of benefits to States, users and providers of services, the need for technical cooperation in the implementation and efficient operation of CNS/ATM systems." It decided that:

> "Towards this end, ICAO shall play its central role in coordinating technical cooperation arrangements for CNS/ATM systems implementation. ICAO also invites States in a position to do so to provide assistance with respect to technical, financial,

managerial, legal and cooperative aspects of implementation . . . In addition, ICAO shall facilitate the provision of assistance to States with regard to the technical, financial, managerial, legal and cooperative aspects of implementation."

15.19 The Council, in defining the ICAO policy on CNS/ATM systems implementation, stressed the need for the ICAO Technical Co-operation Programme to assist States in the transition to CNS/ATM systems and stated "that, on a priority basis, ICAO undertake to take action to encourage multilateral and bilateral agreements and/or to secure the necessary funds to support technical cooperation programmes . . ., and encourage States and stakeholders to provide staff or other resources to support ICAO free of charge . . ."

15.20 The Technical Co-operation Programme is implemented through projects that typically provide assistance to the recipient administration through three means: experts are assigned, either individually or through subcontracted consultant firms, to provide technical advice and transfer of know-how; national staff are trained abroad through the award of fellowship training programmes; equipment is procured, installed and commissioned.

Special features of ICAO Technical Cooperation

Recipient States of technical cooperation

15.21 The ICAO Assembly has urged "Contracting States to give high priority to civil aviation development and, when seeking external assistance for this purpose, to stipulate to funding organizations, through an appropriate level of government, that they wish ICAO to be associated as the executing agency with civil aviation projects that may be funded."

15.22 Based on ICAO's status as a United Nations Specialized Agency, certain important privileges may be applicable to civil aviation authorities purchasing equipment through ICAO, in accordance with the UNDP Standard Basic Assistance Agreement, in place in most recipient States where funding is provided under a UNDP project.

15.23 Governments with insufficient financial resources may be assisted by ICAO in identifying suitable donors for their projects and in the negotiations with these donors of convenient funding arrangements, which could include loans taken to finance technical cooperation inputs. This is consistent with the established ICAO policy that the costs for improvements in civil aviation services and facilities in developing States, which benefit first the users of these facilities, can be included in the cost basis for charges after implementation has been completed. Consequently, user charges can be applied to service loans (i.e. to repay capital and interest) which finance specific facilities and services provided for, and implemented under, the ICAO regional air navigation plans.

Donors and funding organizations

15.24 The ICAO Assembly has recommended "Contracting States with bilateral or other government-sponsored aid programmes to consider the value of using the ICAO Technical Assistance organization in helping to implement their programmes of assistance to civil aviation". It also "recommends to these funding organizations, wherever appropriate, to give preference to ICAO for the identification, formulation, analysis, implementation and evaluation of civil aviation projects in the field of technical assistance."

15.25 ICAO can assist governments in the selection of equipment, equipment manufacturers (through international tender calls), individual consultants and consultancy companies as well as existing training establishments, to meet project goals in the most cost-effective manner. In this respect, ICAO's neutrality allows for the selection of suppliers on a worldwide basis, where required.

15.26 Unless donors and funding organizations specifically ask ICAO not to do so, recipient countries will be informed about the funding sources in order to achieve visibility for the donor/funding organization. Furthermore, contributions received may, in particular cases, be published in the *ICAO Journal* for worldwide distribution. Funds are therefore not anonymous, unless the donor/funding organization chooses to make arrangements to that effect.

15.27 Furthermore, ICAO will implement projects in close coordination with donors and funding organizations, and in accordance with the conditions defined by the donor/funding organization for the use of funds made available, such as limitations on the geographical area for equipment purchases, expert selection and utilization of training institutions. At the same time, ICAO will take responsibility for legally acceptable, technically satisfactory and cost-effective project implementation through comprehensive project monitoring, support, evaluation and reporting.

15.28 Funding organizations such as regional and interregional development banks are responsible for the most cost-effective investments of the funds entrusted to them. It is, therefore, in the interest of these funding organizations to entrust the implementation of civil aviation projects to ICAO, or to at least consult or associate the Organization prior to investing in such projects. This will ensure compatibility with global civil aviation Standards, Recommended Practices and Procedures and achieve an adequate return on the investment for both the contributors and the recipient States.

Strategies for ICAO technical cooperation in CNS/ATM implementation

15.29 Initial assistance for CNS/ATM has been provided to several States from multilateral and bilateral sources, including ICAO, focusing mainly on familiarization, initial transition planning and setting up of pilot projects.

15.30 CNS/ATM familiarization projects were implemented by ICAO in the Asia/Pacific and Latin America Regions in 1995–1996, confirming the requirements and expectations of States for assistance and support through ICAO with their CNS/ATM systems transition and implementation planning and implementation. Additional CNS/ATM familiarization seminars were conducted by ICAO in 1996–1997, either on a subregional basis or at the request of specific States. States have been assisted by ICAO in carrying out cost-benefit analyses for national CNS/ATM systems implementation, based upon ICAO's cost-benefit analysis guidelines. National civil aviation master plans, prepared by ICAO for numerous States, now regularly address phased CNS/ATM systems implementation and training requirements.

15.31 ICAO assistance is currently focused on assisting States and users in deriving early benefits from CNS/ATM through the planning for, and immediate application of, satellite-based systems, such as through WGS-84 surveys and training, GPS, ADS/CPDLC and ATN procedures development and training, as well as providing the basic infrastructure necessary to implement CNS/ATM systems. Providing that technical cooperation in these target areas meets with States' and donors' expectations, it can be assured that financing from States' or donors' funding allocations meets required priorities. ICAO projects are also assisting States in procuring equipment to set up the basic infrastructure necessary to implement CNS/ATM systems.

15.32 In addition, human resources development requirements, commensurate with CNS/ATM systems implementation are being addressed at the national as well as at the regional level through efforts to introduce or expand CNS/ATM-related training courses at national Civil Aviation Training Centres (CATCs). The ICAO TRAINAIR training resource sharing network is proposed as the methodology and vehicle for standardized needs-based and curriculum-driven training introduced at the CATCs, with more basic training carried out through nationally oriented courses and advanced training proposed for regional training courses at regionally oriented CATCs. Highly technical, managerial, institutional, organizational, legal and financial subjects will continue to be dealt with in regional or national seminars led by specialized ICAO staff.

15.33 Cooperative arrangements among Contracting States in a subregion or region, managed by ICAO, concerning a homogeneous ATM area or major international traffic flow, as described in Part I, Chapter 3, similar to cooperative arrangements under implementation, *inter alia,* in ICAO's Universal Safety Oversight Audit Programme and proposed under its Aviation Security and TRAINAIR Programmes, will allow participating States to closely collaborate in planning as well as in systems procurement and training. Cooperative, multinational arrangements, provided these are priority-endorsed by the participating States as well as subregional organizations, where applicable, should fall into line with the latest development focus of at least some multilateral development partners, possibly even with bilateral donors. These cooperative arrangements are consequently proving to be avenues for cost-sharing arrangements of interest to, and suitable for, States as well as a variety of donors, funding organizations and the aviation industry. They have, therefore, potential for substantial application for CNS/ATM systems where inter-State cooperation is essential for cost-effective and harmonious implementation. Additionally, cooperative projects provide a vehicle for technical cooperation among developing countries (TCDC), and regional capacity-building. Recognizing the importance of proper cost-benefit analysis for CNS/ATM planning and implementation, on a country-specific as well as regional basis, TCB continues to participate in an ICAO project team establishing guidelines for CNS/ATM-related business case development.

15.34 The ICAO Strategic Action Plan, based upon the Chicago Convention and adopted in 1997, aims at furthering the safety, security and efficiency of international civil aviation, by developing a vision for harmonious development of international civil aviation on a national and regional basis and reflecting this vision in global planning. The Plan advocates for the Organization to ensure the currency, coordination and implementation of regional ANPs and to provide the framework for efficient implementation of new air navigation systems. To this end, it stresses, *inter alia*, ICAO through its Technical Co-operation Programme assisting States in the mobilization of human, technical and financial resources for civil aviation facilities and services.

15.35 Satellite-based air traffic management, including its supporting communications, navigation and surveillance services, is essentially a global undertaking of air navigation systems' evolution, requiring supporting regional and national infrastructures and human resources. Development and implementation of SARPs for CNS/ATM systems by ICAO are therefore of crucial importance to the international aviation community and in particular to States. While certain States will be in a position to address their CNS/ATM systems development needs using their own resources, external assistance will be required by the vast majority of developing States for providing the infrastructures and qualified human resources needed, as substantiated by the two ICAO surveys briefly described in 15.3 to 15.9. The surveys prove that, if harmonized implementation is to be effected worldwide and efforts are to be made for early benefits to be gained from the new systems, as mandated by the ICAO Assembly, major efforts must be made by the international aviation and development financing communities to put in place the required regional and national infrastructures, and commensurately developed human resources, and secure the required funding.

15.36 The ICAO Technical Co-operation Programme has traditionally assisted Contracting States in the establishment and/or upgrading of civil aviation facilities and services in accordance with States' requirements and the regional ANPs. As part of the ICAO Strategic Action Plan, this Programme must place enhanced emphasis upon the implementation of ICAO's SARPs to the greatest possible extent worldwide. Since a substantial part of future SARPs are being geared towards CNS/ATM systems, the ICAO Technical Co-operation Programme will have to play an increasing role in the implementation of these new air navigation systems, including associated facilities, services and related human resource planning and development.

15.37 ICAO will perform its function in CNS/ATM technical cooperation effectively, as mandated by its Assembly (i.e. its 187 Contracting States), and as requested by other international organizations, industry and users through CASITAF and ALLPIRG/Advisory Group meetings and reinforced by its Strategic Action Plan. Recognizing the limited resources of the Technical Co-operation Bureau of ICAO, however, and the continuing restriction of zero growth for ICAO's regular budget, an effective ICAO CNS/ATM Technical Co-operation Programme will require substantial additional external resources, particularly funding, to enable it to perform the functions and to implement projects relating to the requirements identified in the surveys carried out.

15.38 For the ICAO CNS/ATM Technical Co-operation Programme to fulfil this mandate and the strategic functions envisaged, it will focus on activities that are at the core of States' and users' interests, and for which funding consequently can be assured. While harmonized — "seamless" — implementation of CNS/ATM systems worldwide is the main concern of the international aviation community, initial areas to be focused upon will necessarily be those which generate early benefits to users and, hence, have the added attraction of economic value, i.e. an immediate return on investments made.

15.39 To be in a position to better respond to States' and users' requirements, the ICAO Technical Co-operation Programme — being a non-commercial entity and traditionally assisting its developing Contracting States mainly through governments — has therefore embarked upon the expansion of its resource base by focusing on non-traditional development partners and funding sources. These non-traditional development partners and funding sources include not-for-profit interregional and regional development banks and financing institutions, international organizations and associations and, to a limited extent, industry and service providers. Entities operating in civil aviation on a purely commercial basis are, so far, not in a position to collaborate with ICAO contractually, other than as subcontractors.

15.40 With this aim of expansion of its resource base, the ICAO TCB will continue to present to development and financing partners its capabilities and experience in the implementation of civil aviation projects worldwide. In particular, emphasis has been placed on the presentation of the unique values it can contribute to projects aimed at the upgrading of civil aviation facilities and services as part of CNS/ATM systems implementation planning worldwide. Resource mobilization will, therefore, continue to be one of the main activities of TCB. Funding sources, such as Bretton Woods institutions, regional development banks and industry will be approached to fund the projects.

15.41 Results of initial projects carried out with non-traditional development and financing partners are encouraging because they underscore large areas of common interest where ICAO is in a unique position to contribute the required technical and managerial expertise and experience in an objective manner, thus ensuring the provision of balanced advice, in the ultimate interest of the recipient States. In addition, ICAO, being a not-for-profit development partner, is able to provide cost-effective services, thereby assisting financing partners and recipients in conserving scarce resources. These initial projects, however, also underscore the necessity for sufficient funding to carry out, through the ICAO Technical Co-operation Programme, project development activities expected by States.

15.42 As ICAO's most prominent goal is to provide its Contracting States with assistance in the implementation of SARPs worldwide, ICAO's Technical Co-operation Programme will associate itself with as many CNS/ATM-related civil aviation development efforts as possible, in the ultimate interest of States, as this would contribute to ensuring harmonized and technically acceptable implementation. Financing of a healthy, relevant and effective ICAO Technical Co-operation Programme, particularly for CNS/ATM is, therefore, in the interest of all ICAO Contracting States, inasmuch as harmonized and SARPs-compliant CNS/ATM implementation results in substantially enhanced safety and efficiency of civil aviation worldwide, eventually bringing multi-billion dollar savings to service providers, industry and users.

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APPENDIX A TO CHAPTER 15

CNS/ATM ASSISTANCE REQUIREMENTS OF DEVELOPING ICAO CONTRACTING STATES, BY PIRG

ICAO PIRGs	Assistance needs assessment (No. of States)	Implementation planning including cost-benefit analyses (No. of States)	Systems procurement/ installation/ commissioning (No. of States)	Human resources planning/ development (No. of States)	Seminars/ workshops (No. of States)	Seminars/workshops (Subjects/numbers)
APANPIRG	22	20	19	21	18	GNSS/42 GPS/23 ATN/43 AMSS/32 RNP/37 ADS/39 WGS/34 LEG/36 OWN/29 INST/33 ECON/37 OTH/6
APIRG	26	24	22	26	22	GNSS/17 GPS/26 ATN/23 AMSS/16 RNP/18 ADS/23 WGS/19 LEG/18 OWN/20 INST/18 ECON/19 OTH/16
EANPG	0	0	0	0	0	0
GREPECAS	16	14	14	13	13	GNSS/22 GPS/19 ATN/16 AMSS/15 RNP/15 ADS/19 WGS/13 LEG/11 OWN/11 INST/12 ECON/10 OTH/1
MIDANPIRG	4	3	4	4	3	GNSS/3 GPS/3 ATN/3 AMSS/3 RNP/2 ADS/3 WGS/3 LEG/1 OWN/1 INST/1 ECON/2
TOTAL	68	61	59	54	56	GNSS/84 GPS/71 ATN/85 AMSS/66 RNP/72 ADS/84 WGS/69 LEG/66 OWN/61 INST/64 ECON/68 OTH/23

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APPENDIX B TO CHAPTER 15

INDICATED PREFERRED SOURCE OF CNS/ATM ASSISTANCE FOR DEVELOPING/LEAST DEVELOPED ICAO CONTRACTING STATES, BY PIRG

ICAO PIRGs	No. of questionnaires sent to developing/least developed* countries	No. of replies received from developing/least developed countries	No. of replies received from developing/least developed countries requiring assistance	Percentage of developing/least developed countries requiring assistance from ICAO	Percentage of developing/least developed countries requiring assistance from other sources** in certain specific areas
APANPIRG	DCs: 19 LDCs: 10	DCs: 18 LDCs: 7	DCs: 15 LDCs: 7	DCs: 66% LDCs: 100%	DCs: 13% LDCs: 57%
APIRG	DCs: 18 LDCs: 31	DCs: 10 LDCs: 17	DCs: 9 LDCs: 17	DCs: 90% LDCs: 88%	DCs: 80% LDCs: 35%
EANPG	DCs: 2 LDCs: 0	DCs: 2	0		
GREPECAS	DCs: 28 LDCs: 1	DCs: 17 LDCs: 1	DCs: 15 LDCs: 1	DCs: 100% LDCs: 100%	DCs: 53% LDCs: 0
MIDANPIRG	DCs: 15 LDCs: 2	DCs: 6 LDCs: 1	DCs: 3 LDCs: 1	DCs: 75% LDCs: 100%	DCs: 50% LDCs: 100%
TOTAL	DCs: 82 LDCs: 44	DCs: 53 LDCs: 26	DCs: 42 LDCs: 26	DCs: 83% LDCs: 97%	DCs: 49% LDCs: 48%
Total responses received from developing/least developed ICAO Contracting States by the end of April 1997: 79.					

* Developing country: DC, least developed country: LDC: According to classification by the United Nations in developing and least developed countries.

** Some responses indicated assistance requirements from ICAO and from other sources.

Chapter 16

ENVIRONMENTAL BENEFITS ASSOCIATED WITH CNS/ATM INITIATIVES

BACKGROUND

Aviation and the environment

16.1 Against a background of increasing concern regarding the impact of aircraft engine emissions on the environment, ICAO has been considering what steps could be taken by the international aviation community to control emissions.

16.2 Aircraft engines burn fuel, producing emissions that are similar to other emissions resulting from fossil fuel combustion. However, aircraft emissions are unusual in that to a significant degree they are emitted at altitude. These emissions give rise to important environmental concerns regarding their global impact and their effect on local air quality.

16.3 At a global level, the principal concern is aviation's contribution to climate change. The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) requires developed countries to reduce their collective emissions of greenhouse gases by approximately 5 per cent by the period 2008–2012, compared to 1990. These targets do not apply to emissions from international aviation. Instead, Article 2, paragraph 2 of the Kyoto Protocol states that the responsibility for limiting or reducing emissions from international aviation shall fall to the UNFCCC parties, working through ICAO.

16.4 Future concerns about aviation's role in both climate change and local air quality are largely due to the projected continued growth in this sector. While past technological improvements have reduced the growth rate of emissions and this progress is expected to continue in the future, total emissions will nevertheless continue to increase. For example, the Intergovernmental Panel on Climate Change (IPCC)'s report projects growth in the sector of 5 per cent per year between 1990 and 2015 with CO_2 emissions growing at 3 per cent annually over the same period.

16.5 Against this background, ICAO's Committee on Aviation Environmental Protection (CAEP) has been studying possible means to reduce aircraft engine emissions including the reduction at source, through operational measures or using market-based options.

16.6 In addressing concerns associated with aircraft engine emissions, CAEP is guided by the following principles:

a) measures to address emissions should take into account environmental need, technical feasibility and economic reasonableness;

b) measures to address emissions should also take into account any potential implications for safety, which must not be compromised, and for aircraft noise. Measures aimed at one type of emission (for example, CO_2) or one emission-related problem (for example, climate change) should take into account any potential implications for other types of emissions or for other emission-related problems;

c) measures to address emissions should be developed on a harmonized worldwide basis, wherever possible.

Reducing fuel burn through improved operational measures

16.7 Currently, aircraft operations often involve indirect routings, non-optimal flight profiles, congestion resulting in airborne holding and queuing, delay and other factors that may contribute to increased or unnecessary fuel burn and associated emissions. CAEP is undertaking an initial analysis of the impact on aircraft emissions from the planned CNS/ATM systems enhancements and will make the results available to those involved in planning future air traffic improvements at the regional level.

The initial CNS/ATM study and the extension for a global analysis

16.8 At the direction of the Council, CAEP's Working Group 4, Emissions — Operational Issues, initiated a study of the environmental benefits made possible through the implementation of CNS/ATM systems. This work is driven in part by the IPCC Special Report on Aviation and Global Atmosphere (1999), which concluded: "As the aviation industry grows more and more rapidly, the impact of air traffic operations on the global atmosphere becomes increasingly important. Efforts to control or reduce the environmental impact of air traffic have identified a range of options that might reduce the impact of aviation emissions. In particular, it is expected that improvements in air traffic management (ATM) and other enhanced operational procedures for air traffic systems could help reduce aviation fuel burn, and thereby reduce the levels of aviation emissions."

16.9 The terms of reference (TOR) of Working Group 4 established by the CAEP are to "quantify and ensure that relevant environmental impacts of aviation emissions are taken into account in the global and regional planning of CNS/ATM and incorporated into airport planning." In response to the TOR, CAEP directed Working Group 4 to "evaluate the potential impact of CNS/ATM systems enhancements and recommended actions to facilitate implementation on a regional and global basis."

16.10 The data from the first analysis were presented to the CAEP in January 2001 with preliminary results referring to the benefits of implementation of CNS/ATM systems in two regions of the world. These regions have been used for developing a parametric model. The actual TOR established that Working Group 4 would expand this model to the rest of the world in cooperation with the PIRGs and the ICAO Secretariat.

16.11 Potential benefits from CNS/ATM systems for this initial study were based on planned implementation strategies for Europe and the United States.

THE PARAMETRIC MODEL

Basis of the model

16.12 Implementation of CNS/ATM systems will generally have benefits in three areas: improved airport capacity that reduces delays at congested airports, shorter cruise times through the use of more direct routes, and an increase of unimpeded taxi times. The model looks at many types of CNS/ATM systems enhancements, e.g. route network optimization through reduced separations, airspace management and civil/military coordination, collaborative flight planning and re-routing, strategic capacity management, reduced vertical separation minima (RVSM) and wind-optimized direct routes resulting in shorter cruise times.

Summary of the methodology

16.13 The scope of the study included baseline and optimized scenarios for the years 1999, 2007, 2010 and 2015. A baseline scenario was established that showed the case without CNS/ATM initiatives, but with non-CNS/ATM measures such as an additional runway or aircraft engine improvements included. Then, an optimized scenario was developed that incorporated planned CNS/ATM measures as well as the non-CNS/ATM measures included in the baseline scenario.

16.14 In the parametric model, the following variables that directly influence fuel consumption were identified for use in the model:

a) phase of flight;

   — surface (taxi-in and taxi-out)

   — take-off

   — initial climb below 3 000 ft (914.4 m)

   — cruise, phase of flight occurring above 3 000 ft (914.4 m)

   — final approach below 3 000 ft (914.4 m)

   — aircraft type and engine

b) airborne delays;

c) ground delays (taxi-in and taxi-out delays);

d) approach delays (air holds in the "last tier" due to congestion at the destination airports);

e) demand (the number of current and forecasted flights between city-pairs);

f) traffic growth rate (using the Forecasting and Economic Analysis Support Group's (FESG) annual growth rate); and

g) rate of improvement in aircraft performance and fleet mix changes (using FESG's assumption of a 20 per cent total reduction in fuel burn rates in the next 20 years).

16.15 Other variables, such as airport capacity and weather conditions, can impact upon one of the direct variables described above. For example, demand growth and airport capacities can affect ground and arrival delays. CNS/ATM measures may increase airport capacities. Queuing theory approximations are used to estimate the percentage change in delay caused by capacity or demand increases. Similarly, airport capacities under visual flight rules (VFR) and instrument flight rules (IFR) conditions are estimated for the baseline and optimized scenarios.

Model input

16.16 The following summarizes the input needed by the model to assess the potential fuel savings from any CNS/ATM systems implementation plan. Some of the data is universal (i.e. specific aircraft fuel burn rates) while some of it is specific and unique to each region. To expand the study to other ICAO regions, and to develop a truly global assessment, specific or unique data would need to be gathered from each region based on regional CNS/ATM implementation plans. Where region-specific data are not available, global assumptions or other available data can be used. The model uses the following input:

a) planned CNS/ATM enhancements;

b) fuel burn rates (lbs/min) for phase of flight; idle, take-off, climb (up to 3 000 ft (914.4 m)) and approach;

c) minimum take-off, climb and approach times;

d) "cruise" phase median, low and high fuel burn rate (lbs/min) for existing aircraft types using all flights, and flights between city-pairs of less than 500 miles great circle distance;

e) identification of aircraft types (regional fleet mix), and future fleet mix forecast;

f) the amount of delay on the ground (taxi) and on approach (arrival delay due to congestion at the airport) for major airports in the region;

g) current and future airport capacities and improvements expected to result from airport capacity changes, physical and procedural, and from CNS/ATM initiatives;

h) identification of capacity-constrained airports;

i) unimpeded taxi times for major airports;

j) airport weather information (average VFR and IFR);

k) future growth forecast;

l) estimated approach delays;

m) estimated taxi-out and taxi-in delays; and

n) current routes for baseline scenarios.

Initial findings of the study

16.17 Within the time frame under consideration (1999–2015), global air traffic is expected to increase by approximately 61 per cent (source: FESG). In the same time period, fuel consumption and CO_2 emissions are projected to increase by just 37 per cent.

16.18 Fuel burn and CO_2 emissions are growing less quickly than traffic because of the introduction of more efficient engine technology, aircraft retirement and fleet expansion. This reflects the already strong commitment of the aviation industry to fuel conservation and the consequent emission reductions.

16.19 The preliminary results of this study show that by 2015 there will be an additional benefit of approximately 5 per cent fuel burn and CO_2 emission savings due to the introduction of planned CNS/ATM systems implementation measures within the United States and Europe. This table shows a summary of the annual fuel and CO_2 savings for 2015 from CNS/ATM systems improvements for both the United States (CONUS) and the Europe Civil Aviation Conference (ECAC) States of the European Region. The results are displayed by flight segment.

Flight segment	*CONUS*	*ECAC*
Above 3 000 ft (914.4 m)	5%	4%
Below 3 000 ft (914.4 m)	5%	7%
Surface	11%	3%
Whole flight	5%	5%

Preliminary results show savings of a similar order of magnitude for oxide of nitrogen (NO_X), unburned hydrocarbon (HC) and carbon monoxide (CO), but the work is subject to further analysis, verification and validation.

FUTURE ACTIVITIES

16.20 The model can be improved to encompass on a more comprehensive basis all regions of the world and to become more user-friendly. After subsequent steps are achieved and the material matures, the Global Plan will be updated accordingly. Future work will focus on the following activities:

a) gathering information on CNS/ATM systems initiatives in other regions of the world to expand the model in order to represent a worldwide result;

b) performing additional simulations to estimate the impact of specific technology enhancements on flight efficiency which result in changes to fuel usage and emissions. A more detailed examination of the effect of altitude on the emissions and fuel usage will be performed;

c) enhancing the parametric model as new information becomes available. Various parameters will be calibrated to better represent different regions of the world; and

d) enhancing the user interface of the parametric model so any decision-maker can use it easily to perform sensitivity analyses. This would enable the decision-maker, for example, to change the forecast demand input and compare the resulting fuel savings due to CNS/ATM initiatives or to change the schedule or the impact of one or several CNS/ATM initiatives and compare the resulting fuel savings.

Regional planning considerations

16.21 Regional planning groups should take environmental factors into consideration when developing CNS/ATM systems implementation plans. Although future plans could include developing a user-friendly, stand-alone modelling capability, the current model is run under the auspices of ICAO/CAEP's Working Group 4. Representatives of the PIRGs are encouraged to contact the ICAO Secretariat to initiate the process to evaluate the environmental benefits of planned CNS/ATM systems enhancements.

16.22 After initial contact with the Secretariat, arrangements will be made to gather the appropriate modelling data for a particular region to begin the modelling effort. The data as described above can be collected from existing databases, from direct interviews between representatives from the regional planning groups and the modellers, or by the development of regional-specific assumptions.

16.23 The results of the model can be useful in providing national decision-makers within the various regions with information upon which to base airspace architecture decisions and in providing the international climate change body with information on what the aviation industry is doing now to protect the environment in the future.

PART II

Facilities and Services for the Implementation of the Global Plan

Chapter 1
INTRODUCTION

GENERAL

1.1 The Global Air Navigation Plan for CNS/ATM Systems (Global Plan) has a clear and functional relationship to the regional air navigation plans (ANPs). This has been accomplished by dividing the Global Plan into two parts: the *Operational Concept and General Planning Principles* (Part I) and the *Facilities and Services for the Implementation of the Global Plan* (Part II). Part I provides guidance for the further development of the basic operational requirements and planning criteria (BORPC) of the regional ANPs. It also provides the global guidance needed to plan for the facilities and services required to support the implementation of CNS/ATM systems at the regional level. These facilities and services are then identified in the facilities and services implementation documents (FASIDs) of the regional plans and subsequently reflected in Part II of the Global Plan. Part II of the Global Plan has a corollary and ongoing interrelationship with the FASIDs of the regional ANPs.

PART II OF THE GLOBAL PLAN

1.2 Part II of the Global Plan depicts the facilities and services to be provided to satisfy the requirements for implementation of global CNS/ATM systems. It will be amended as necessary to reflect changes in facilities and/or services emanating from regional type air navigation meetings or through the amendment procedure described in the regional ANPs. The information in this part, therefore, largely reflects what has been agreed to through the normal regional planning processes, and as such, requires no separate, formal approval process.

1.3 Part II will serve the purpose of clearly identifying the inter-regional CNS/ATM systems infrastructure, which is necessary to support the implementation of global CNS/ATM systems. It will also serve as an executive register of the progress achieved by the PIRGs and of the work remaining.

1.4 Parts I and II of the Global Plan together provide the means for a step-by-step approach to planning for implementation of global CNS/ATM systems. To begin the process, several homogeneous ATM areas and major international traffic flows have been identified in Part II, Chapter 4.

1.5 As the ATM operational concept and the associated concepts of required communication performance (RCP)*, required navigation performance (RNP), required surveillance performance (RSP)* and required total system performance (RTSP)* mature, they should be integrated into the planning process so that further development can take place. Planning and implementation should therefore be seen as a continuing, evolving and maturing process.

1.6 Based on the above, PIRGs are responsible for the integration and harmonization of CNS/ATM systems plans for their various regions, while ICAO, through this Global Plan, ALLPIRG meetings, worldwide conferences, and an inter-regional coordination mechanism, will carry out the inter-regional coordination to ensure global compatibility, harmonization and seamlessness amongst the systems.

1.7 The tables in this part, when completed, will form the framework to guide the implementation of CNS/ATM systems on a global basis, using the traditional regional planning processes, leading to a global, integrated ATM system.

* Emerging concept or technology — consensus still to be reached.

Chapter 2

REGIONAL PLANNING AND IMPLEMENTATION

INTRODUCTION

2.1 The planning and implementation of CNS/ATM systems takes place primarily at the regional level. The following material is intended to support the regional process. It forms the basic structure for regional CNS/ATM systems plans and their transition.

Organizational structure

2.2 In each ICAO region, the development and updating of the regional ANP is a primary responsibility of the planning and implementation regional group (PIRG). The PIRG should therefore be considered as an effective vehicle for the development of a regional plan for the planning and implementation of CNS/ATM systems. A separate expert subgroup may be established by the PIRG to specifically address the planning and implementation of CNS/ATM systems. Such a subgroup should include the States of the region, user representatives and service providers of CNS/ATM systems. The terms of reference of the subgroup should consist of at least the following elements:

— review, monitor, and identify any shortcomings or deficiencies in the present CNS/ATM systems in the region;

— develop a regional plan for the implementation of CNS/ATM systems based on the Global Air Navigation Plan for CNS/ATM Systems (Global Plan) and, in particular, the global planning methodology identified in Chapter 3 of Part I;

— coordinate the updating, on a regular basis, of the regional CNS/ATM systems implementation plan;

— update, on a regular basis, Chapter 1 and the tables in Part II of the Global Plan;

— monitor research and development, and trials and demonstrations within the region;

— monitor information received from other regions;

— coordinate State, international organization, airline and industry plans for the implementation of the regional CNS/ATM systems implementation plan;

— provide a forum for the active exchange of information among States in order to resolve planning and implementation problems as they arise; and

— facilitate the transfer of CNS/ATM systems expertise, equipment, trials, data, etc. among States.

Process description

2.3 The PIRG should review the objectives and functions of the Global Plan, and the Statement of ICAO Policy on CNS/ATM Systems Implementation and Operation with respect to each particular region. Figure II-2-1 illustrates the approach to planning for CNS/ATM systems based on homogeneous ATM areas and/or major international traffic flows.

2.4 Based on specific features of a geographical nature, traffic flows, airspace structure, essential facilities and services, traffic density and the level of sophistication required, the region should be divided, if necessary, into a number of homogeneous areas, taking into account the priority structure of CNS systems elements and areas of applicability with regard to implementation (3.4 of Part I refers). Major international traffic flows should be identified wherein it is logical to specify a detailed plan for the implementation of CNS/ATM systems (3.6 of Part I refers). An evaluation of present CNS/ATM systems in the homogeneous areas and/or major traffic flows should be made and any shortcomings identified.

2.5 For the homogeneous ATM areas or major international traffic flows, an air traffic forecast of the growth of air transport, including commuter and general aviation, should be developed. Based on this forecast, a

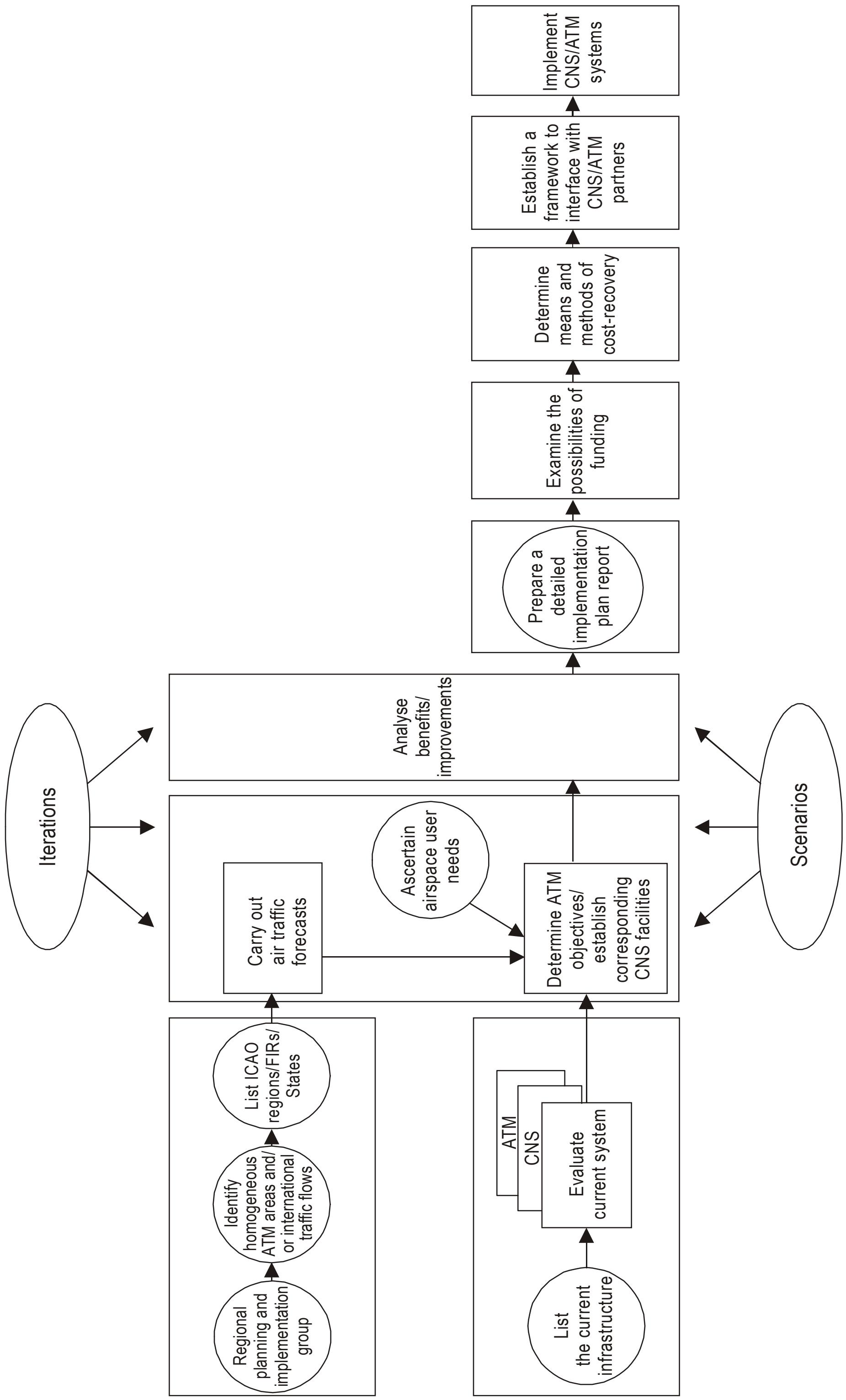


Figure II-2-1. Approach to planning for CNS/ATM systems on the basis of homogeneous ATM areas and/or major international traffic flows

specific ATM plan should be developed. During the process, the specific needs of the users and service providers should be taken into account.

2.6 Subsequent to the development of ATM plans, ATM objectives and CNS requirements should be determined. After an analysis, decisions on technical and operational systems implementation time lines should be reflected in regional implementation tables and in the tables of Part II of the Global Plan.

2.7 Priorities should be established in terms of time-scales and in response to identified constraints and the requirements of States as to the systems and areas of applicability whereby the most immediate benefits could be provided or where early implementation may be most likely. The planning methodology in 3.15 of Part I of the Global Plan provides a step-by-step approach for PIRGs to follow. The establishment of milestones should take into account the following key events relative to each system:

a) completion of pertinent tasks by relevant ICAO groups, including the adoption of SARPs;

b) adoption of relevant avionics Standards;

c) completion of relevant research and development, and application developments;

d) availability of sufficient satellite capacity;

e) availability of avionics;

f) completion of pre-operational trials and the validation process;

g) availability of suitable procedures;

h) availability of ground infrastructure;

i) completion of training;

j) effective date for mandatory carriage, where appropriate; and

k) withdrawal of obsolete systems elements (airborne and ground).

2.8 The regional CNS/ATM systems plan, when finalized, should reflect technical and operational requirements. To facilitate implementation, regional planning should take into account each element of the CNS systems (tables of Chapters 6, 7 and 8 of Part II refer) and relevant objectives of the ATM as identified in the table in Chapter 4 of Part II.

REGIONAL OFFICES AND THEIR ASSOCIATED PLANNING AND IMPLEMENTATION REGIONAL GROUPS (PIRGs)

ICAO Bangkok — ASIA/PAC Air Navigation Planning and Implementation Regional Group (APANPIRG)

ICAO Cairo — Middle East Air Navigation Planning and Implementation Regional Group (MIDANPIRG)

ICAO Lima/Mexico — CAR/SAM Regional Planning and Implementation Group (GREPECAS)

ICAO Mexico — North American Planning Group (NAMPG)

ICAO Dakar/Nairobi — AFI Planning and Implementation Regional Group (APIRG)

ICAO Paris — North Atlantic Systems Planning Group (NAT SPG); European Air Navigation Planning Group (EANPG)

REGIONAL PLANNING GROUPS AND THEIR AREAS OF RESPONSIBILITY

Asia/Pacific Air Navigation Planning and Implementation Regional Group (APANPIRG)

Chairman of APANPIRG: Mr. H.S. Khola (India)

Secretary: Mr. L.B. Shah (ICAO Regional Director, Bangkok)

Chairman of CNS/ATM IC Subgroup: Rodney Bracefield (New Zealand)

2.9 The ICAO Council established the APANPIRG in 1991. Its membership consists of fifteen States: Australia, Bangladesh, China, Fiji, France, India, Indonesia, Japan, Malaysia, New Zealand, Pakistan, the Republic of Korea, Singapore, Thailand and the United States. The CNS/ATM Subgroup was set up in the same year to produce the CNS/ATM plan for the ASIA/PAC Regions. The broad plan was produced in 1994 and contains traffic forecasts, a description of the CNS/ATM system, transition guidelines, trials and developments and an implementation summary. The plan is updated annually to keep pace with the progress of developments.

2.10 In 1994, the CNS/ATM Subgroup was re-formed to become the CNS/ATM Implementation Coordination Subgroup in order to emphasize that implementation was being carried out and was being coordinated on a regional basis.

Middle East Air Navigation Planning and Implementation Regional Group (MIDANPIRG)

Chairman of MIDANPIRG: Mr. A. Al-Harthy (Oman)

Secretary: Mr. A. Zerhouni (ICAO Regional Director, Cairo)

Chairman of CNS/ATM Subgroup: Mr. M. Al Alawi (Saudi Arabia)

2.11 The ICAO Council established the MIDANPIRG in 1993. Its membership is drawn from Bahrain, Egypt, Iran (Islamic Republic of), Jordan, Lebanon, Oman, Saudi Arabia and the United Arab Emirates.

2.12 MIDANPIRG was tasked with ensuring the continuous and coherent development of the Middle East Regional Air Navigation Plan as a whole and in relation to those of adjacent regions.

2.13 The first meeting of the CNS/ATM Subgroup, established to structure the planning and implementation of CNS/ATM systems within the Middle East Region, was held in January 1995. In 1997, the group developed a draft regional plan for CNS/ATM systems. The MIDANPIRG, in September 2000, adopted the first edition (2000) of the CNS/ATM implementation plan for the MID region, which will be subject to ongoing updates.

Africa-Indian Ocean Planning and Implementation Regional Group (APIRG)

Chairman of APIRG: Mr. Mohamed Cherif (Tunisia)

Secretary: Mr. A. Cheiffou (ICAO Regional Director, Dakar)

Chairman of CNS/ATM/Implementation Coordination Subgroup: Mr. G. Elefteriou (Côte d'Ivoire)

2.14 The APIRG was set up by the ICAO Council in 1980. This group is composed of members from States in the Africa-Indian Ocean Region, ensuring a balanced representation of the region as a whole. The current membership (twenty-nine Member States) of APIRG includes Angola, Algeria, Cameroon, Congo, Côte d'Ivoire, Democratic Republic of the Congo, Egypt, Eritrea, Ethiopia, France, Gabon, Ghana, Guinea, Kenya, Lesotho, Malawi (also representing Zimbabwe), Mali, Mauritania, Morocco, Niger, Nigeria, Senegal (also representing Gambia), South Africa, Spain, Togo, Tunisia, Uganda, United Republic of Tanzania and Zambia, and three international organizations.

2.15 The Africa-Indian Ocean implementation plan for CNS/ATM systems, as developed by the CNS/ATM Subgroup, was adopted by APIRG at its tenth meeting, held in June 1996, and was endorsed by the Seventh Africa-Indian Ocean Regional Air Navigation Meeting (AFI/7), held in Abuja, Nigeria, in May 1997. This implementation plan is being reviewed and updated periodically by APIRG, based on input from States and international organizations.

North Atlantic Systems Planning Group (NAT SPG)

Co-chairpersons of NAT SPG: Vacant

Secretary: Mr. C. Eigl (ICAO Regional Director, Paris)

CNS/ATM Subgroup: No subgroup at this time (fully integrated into NAT SPG)

2.16 The ICAO Council established the NAT SPG in 1965 as the first regional planning group covering the North Atlantic Region. Canada, Denmark, France, Iceland, Ireland, Norway, Portugal, the United Kingdom and the United States are members, while the Russian Federation, Spain, the International Mobile Satellite Organization (Inmarsat) and several international associations and organizations are observers.

2.17 In 1992, the group was tasked with developing proposals for CNS/ATM systems implementation, as well as proposals for institutional arrangements. In 1994, the North Atlantic Implementation Management Group (NAT IMG) was created to coordinate and manage — on behalf of the NAT SPG — the North Atlantic implementation plan.

2.18 The NAT IMG has taken a number of important initiatives since its creation. These include a cost-effectiveness programme, the establishment of a project coordination office and, on 27 March 1997, the introduction of reduced vertical separation minima (RVSM).

North American Planning Group (NAMPG)

Co-chairpersons of Group:
Mr. Ken Moody (Canada)
Mr. Jaime Zapiain (Mexico)
Ms. Carey Fagan (United States)

Secretary: Mr. R. Ybarra (ICAO Regional Director, Mexico)

2.19 In 1994, the Directors of Civil Aviation of Canada, Mexico and the United States agreed to form the North American Planning Group, comprised of these three States, which was established under the auspices of the North American Free Trade Agreement (NAFTA). This group serves as the focal point for the planning and implementation of CNS/ATM systems in the North American Region. Although Mexico is geographically located in the ICAO Caribbean Region, the Directors of Civil Aviation of all three States agreed that, because of common borders, Mexico is more homogeneous, consistent and coherent with the North American Region. Mexico's CNS/ATM plans are also included in the GREPECAS planning process. The ICAO NACC Office provides the necessary coordination support for the group.

2.20 The group formulated the CNS/ATM systems plan for the region at its first meeting, held in June 1995. The plan has been reviewed and updated annually and in February 1999, the plan was reformatted using the ICAO Global Plan as the model. The plan now includes the Gulf of Mexico airspace as a homogeneous area and was submitted to ICAO in April 1999 for consideration. The nomination of Canada's Northern and Arctic Domestic Airspace as a homogeneous ATM area is also under consideration by Canada. In 2001, the group plans to update the North American Air Navigation Plan and submit a proposal for amendment.

2.21 The United States Federal Aviation Administration (FAA) formed the Gulf of Mexico Work Group (GOMWG) in early 1999 to address capacity limitations and to improve safety in the Gulf of Mexico airspace.

2.22 The GOMWG is co-chaired by the United States (FAA), Mexico (SENEAM) and the Air Transport Association (ATA). The work group is supported by a steering committee and two subgroups. The Steering Committee provides technical support and guidance to the entire body. The Communications, Navigation, Surveillance, Weather and Automation Subgroup (CNSWA) focuses on recommending solutions that address communications, navigation, surveillance, weather collection and distribution, and automation shortcomings. The Airspace and Procedures Subgroup seeks to recommend solutions that involve airspace allocation and procedural issues.

Caribbean/South American Regional Planning and Implementation Group (GREPECAS)

Chairman of GREPECAS: Mr. J.P. Sánchez Dañino (Mexico)

Secretary: Mr. Raymond Ybarra (ICAO Regional Director, Mexico)

Chairman of ATM/CNS Subgroup: To be determined

2.23 The ICAO Council established the GREPECAS in 1990. As a result of the great emphasis placed on activities related to CNS/ATM systems, the CNS/ATM Subgroup was formed. This subgroup proceeded to develop a regional implementation plan, which was approved by GREPECAS at its sixth meeting, held in 1996. At the same time, the subgroup was re-formed to become the CNS/ATM Implementation Coordination Subgroup, which developed an action plan for the implementation of CNS/ATM systems. During the GREPECAS/9 Meeting (August 2000) a restructuring of GREPECAS was made by which means the CNS/ATM Subgroup was disbanded, creating instead the ATM/CNS Subgroup, composed of the ATM and CNS Committees, which will have as an objective, among others, to promote and follow up the implementation of the CNS/ATM system required in the CAR/SAM ANP.

2.24 The membership of GREPECAS comprises Antigua and Barbuda (representing Dominica, Grenada, Saint Kitts and Nevis, Saint Lucia, and Saint Vincent and the Grenadines), Argentina, Barbados, Brazil, Chile, Colombia, Costa Rica, Cuba, Ecuador (in rotation with Panama, Guyana and Suriname every two years), France, Mexico, Paraguay (in rotation with Bolivia and Uruguay every two years), Peru, Trinidad and Tobago, the United Kingdom, the United States and Venezuela.

European Air Navigation Planning Group (EANPG)

Chairman of EANPG: Mr. Karsten Theil (Denmark)

Secretary: Mr. C. Eigl (ICAO Regional Director, Paris)

CNS/ATM Subgroup: Established by EANPG/42 (4 to 7 December 2000)

2.25 The ICAO Council established the EANPG in 1972. In order to meet the new challenges, the EANPG Programme Coordination Group (COG) was created in 1995 to assist the EANPG Chairman and the ICAO Secretariat in facilitating and coordinating the work of the EANPG between meetings, thus maintaining a dialogue with other regions and avoiding duplication of work. The EANPG directly monitors progress made with the implementation of CNS/ATM systems in the European Region.

2.26 The EANPG is comprised of representatives from Baltic States (Estonia, Latvia and Lithuania), Belarus, Benelux States (Belgium, Luxembourg and the Netherlands), Caucasian States (Armenia, Azerbaijan and Georgia), Central Asian States (Kazakhstan, Krygyzstan, Tajikistan, Turkmenistan and Uzbekistan), Croatia (also on behalf of the former Yugoslav Republic of Macedonia), the Czech Republic, Finland, France, Germany (also representing Austria), Greece, Italy, Portugal, the Russian Federation, Scandinavian States (Denmark, Norway and Sweden), Spain, Switzerland, Turkey, Ukraine and the United Kingdom.

CURRENT STATUS OF PLANNING AND IMPLEMENTATION OF CNS/ATM SYSTEMS

ASIA/PAC Air Navigation Planning and Implementation Regional Group (APANPIRG)

Air traffic management — current status and regional strategy

2.27 The present ATM system in the Asia/Pacific Regions suffers from the following shortcomings:

a) lack of surveillance facilities over large areas of the regions which require relief from congestion;

b) air-route availability constrained by point-source-navigation-aids resulting in choke-points;

c) dissimilar ATS procedures and separation standards causing flight information region (FIR) boundary changes to flight profiles;

d) the uncoordinated provision of present CNS systems resulting in duplication of resources and services;

e) a lack of appropriate parallel ATS route structures that relieve route congestion; and

f) poor-quality communications facilities and language difficulties.

2.28 Adequate surveillance, appropriate parallel ATS route structures, and optimum flight profiles are required in order to overcome the present limitations and to better cope with growth. Language difficulties and coordination procedure problems can be largely resolved by automated data processes. Efficient coordination between adjacent FIRs, and common navigation standards and procedures are also essential to ensure a transparent transfer of ATS responsibility. Due to the large oceanic areas of the Asia/Pacific Regions, only satellite technology can efficiently provide the necessary seamless and flexible regional interface necessary.

General remarks

2.29 As new CNS systems provide for closer interaction between ground systems and airspace users before and during flight, improvements to ATM will permit more flexible and efficient use of the airspace and will enhance traffic safety and regularity of flight. ATM may be viewed as the principal beneficiary of the CNS improvements, i.e. it is the resultant benefits to ATM that constitute the rationale for incurring the costs of CNS improvements. In turn, improvements in ATM will ultimately benefit all airspace users.

2.30 The following changes in ATM are envisaged in the Asia/Pacific Regions and are to be supported by future CNS systems:

a) improved handling and transfer of information between operators, aircraft, and ATS units;

b) extended surveillance by using aircraft positions derived from airborne systems (i.e. automatic dependent surveillance);

c) advanced ground-based data processing systems, allowing for:

   1) the ability to take advantage of the navigation accuracy, in four dimensions, of modern aircraft;

2) improved accommodation of user-preferred flight profiles in all phases of flight, based on the operator's objectives; and

3) improvement in conflict detection and resolution, automated generation and transition of conflict-free clearances and rapid adaptation to changing traffic conditions;

d) these three aims of development, together with improved planning, will allow more dynamic airspace and ATM, particularly in high-density airspace.

Communications — current status
and regional strategy

2.31 The Asia/Pacific Regions are characterized by the use of:

a) data and voice communications for direct satellite/aircraft links in some parts of the regions. High frequency (HF) voice is being maintained during the transition period;

b) very high frequency (VHF) for voice and data communications in many continental and terminal areas;

c) SSR Mode S data link, in the near future, in some parts of the regions for air traffic services (ATS) purposes in some high-density airspace; and

d) ATN, in the future, for the interchange of digital data over dissimilar ground-to-ground and air-ground communications links between end systems.

General remarks

2.32 The Asia/Pacific Regions contain large expanses of ocean where the CNS systems, which could be used, are severely limited. Thus, air-ground communications have been limited to high frequency (HF), often with the need for intermediate communicators. Surveillance has been limited to pilot reports of position via HF communications. These limitations have resulted in the large separations that apply in oceanic airspace. For these reasons, the Asia/Pacific Regions have been quick to embrace the new CNS/ATM systems, particularly controller-pilot data link communications (CPDLC) and automatic dependent surveillance (ADS).

Navigation — current status
and regional strategy

2.33 The Asia/Pacific Regions are characterized by the:

a) progressive introduction of area navigation (RNAV) capability in compliance with required navigation performance (RNP) criteria;

b) use of global navigation satellite system(s) (GNSS) for aircraft navigation;

c) use of instrument landing systems (ILS), GNSS and microwave landing systems (MLS) for approach and landing guidance systems in accordance with the regional strategy adopted by APANPIRG; and

d) progressive withdrawal of current navigation aids (NDB, VOR, DME).

Surveillance — current status
and regional strategy

2.34 The Asia/Pacific Regions are characterized by:

a) the use of SSR Mode A, C and, in the near future, Mode S in some terminal areas and high-density continental airspace;

b) the use of ADS in some parts of the regions; and

c) the diminishing use of primary radar.

Middle East Air Navigation Planning and Implementation Regional Group (MIDANPIRG)

Air traffic management — current status
and regional strategy

2.35 While there are some remote and less developed areas without radar coverage, the MID Region is, in general, well covered by radar. Current air traffic control procedures are therefore mostly based on the use of radar control. There are a small number of fixed RNAV routes in the region. On the majority of routes outside radar coverage within the region, 10 minutes longitudinal separation is applied.

2.36 The CNS/ATM Subgroup has determined the major traffic flows and divided the region into two geographic areas based on these traffic flows. The determination of the overall ATM objectives is ongoing. Regional timescales for the introduction of the various ATM elements of the overall CNS/ATM system have, nevertheless, been produced. The CNS/ATM Subgroup has also established a task force to examine the introduction of RNP and RNAV routes in more detail. Because the development of ATM objectives is not yet complete, and the plans for introductions of RNP and RNAV routes are not finalized, the current timescales could be subject to change as the development work continues.

Communications — current status and regional strategy

2.37 At present, air-ground communications in the region are provided by VHF voice. However, in some parts of the region, air-ground communications are limited to HF. In ground-to-ground communications, the existing low-speed aeronautical fixed telecommunication network (AFTN) system in some parts of the region is not capable of fully supporting the efficient exchange of data required by the present ATS system. Furthermore, ground-ground communications between area control centres (ACCs) are adversely affected by the lack of full implementation of direct-speech circuits.

2.38 Very high frequency (VHF) will remain in use for air-ground voice and data communications in most continental and terminal areas. The SSR Mode S data link will be used for ATS purposes in high-density airspace. The aeronautical telecommunication network (ATN) will provide the interchange of digital packet data between end-users over various air-ground communications subnetworks.

Navigation — current status and regional strategy

2.39 The present infrastructure of NAVAIDs within the MID Region is considered adequate to service the foreseeable navigation requirements of the region.

2.40 RNAV capability, in compliance with RNP criteria, will be progressively introduced. GNSS will provide worldwide coverage and will be used for aircraft navigation and for non-precision-type approaches and, with appropriate augmentation, for Category I approaches.

Surveillance — current status and regional strategy

2.41 Radar coverage in the Middle East is available in most areas, but not in all areas where it is necessary for the provision of efficient ATC and where its provision would be physically possible. For some oceanic or remote areas, surveillance is still limited to pilot reports of position via HF communications resulting in the application of large separation minima.

2.42 In the future, SSR Modes A/C will be used in terminal areas and high-density continental airspace. ADS will be used over oceans/continental airspace and possibly as a back-up to SSR in high-density traffic areas. The use of primary radar will diminish.

AFI Planning and Implementation Regional Group (APIRG)

Air traffic management — current status and regional strategies

2.43 In accordance with the guiding principles adopted in the AFI CNS/ATM Implementation Plan (Doc 003), the implementation of CNS/ATM in the region is gaining momentum. Fully conscious of the implementation goals and strategies of the global ATM, the APIRG and its relevant subgroups (ATS, CNS/ATM and COM Subgroups) have already laid down the necessary framework for the evolutionary implementation of CNS/ATM in the region. The implementation strategy is aimed at taking advantage, in a timely manner, of those individual elements of the CNS/ATM systems for which positive benefits have been identified. Since effective implementation of the CNS/ATM Plan will be highly dependent on Human Factors (man-machine interface), the need to maintain quality assurance/proficiency checks for ATS personnel has been identified.

2.44 However, there are many shortcomings and deficiencies in the region, which impede the smooth transition towards new systems; consequently substantial resources are dedicated to the elimination of these inadequacies. The major challenge still remains in the field of communications; although significant improvements have been noted through the use of VSAT technology, reliable means of communications (HF, VHF and ATS/DS) and proper coordination still remain a major requirement in the region.

2.45 The implementation coordination groups (ICGs) which have been established for the 10 homogeneous areas of routing (AR-1 to AR-10) based on traffic affinities have already met on various occasions, and implementation is being carried out in a coordinated and coherent manner.

2.46 Emphasis is being put on the implementation of the following elements:

— reduction of longitudinal separation to 10 minutes;

— implementation of RNP 10 and RNP 5 along major traffic flows;

— implementation of random routing areas;

— planning for the implementation of reduced vertical separation minimum between FL 290 and 410 inclusive;

— progressive introduction of ATC automation;

— reduction of lateral separation from 100 NM to 50 (in RNP 10 environment) and eventually to 30 NM (in RNP 4 environment) in selected airspace;

— progressive introduction of longitudinal RNAV/RNP separation minima of 10 minutes and/or 80 NM RNAV-derived distance, in selected airspace from 2001 onwards;

— progressive introduction of automatic dependent surveillance (ADS) in selected airspace from 2000 onwards; and

— completion of implementation of WGS-84-based coordinates to be pursued as a matter of high priority to facilitate introduction of GNSS.

2.47 The need for inter-regional cooperation for the harmonization of systems and procedures cannot be over-emphasized.

Airspace management

2.48 In fostering the implementation of the CNS/ATM Plan, the concept of a cooperative approach to airspace management has been emphasized. Several regional bodies have already agreed to establish a common upper airspace ATM system in their areas.

Communications — current status
and regional strategy

2.49 Aeronautical mobile service (AMS) is mainly provided by HF voice within most of the FIRs, and by VHF voice within terminal areas. Efforts will continue on the implementation of remote and extended range VHF.

2.50 The aeronautical fixed telecommunication network (AFTN) is characterized by analog and low-speed circuits which do not meet the requirements for efficient support of data exchange in the present ATS system. ATS/DS communications between ATS units are also adversely affected by shortcomings and deficiencies. In an endeavour to remedy this situation, full implementation of the AFS plans and the upgrade of AFTN circuits are being pursued vigorously. The transition to the ATN will be initiated by migrating to the ATS Message Handling System (AMHS).

2.51 Very high frequency (VHF) voice will remain the main form of pilot-controller communications throughout the region within the time frame envisaged in the first stage of the CNS/ATM implementation plan. Meanwhile, the early introduction of data link communications is supported and encouraged with the initial main objective of reducing air-to-ground communications workload.

Navigation — current status
and regional strategy

2.52 Since the present infrastructure of navigational aids is not considered adequate to service the foreseeable navigation requirements of the AFI Region, RNAV capability, in compliance with RNP criteria, will be progressively introduced.

2.53 **Terminal areas.** As a general principle, navigation facilities in TMAs must allow for navigation during departure, holding and approach with the required degree of accuracy. For the time frame encompassed by the first stage, the standard navigation aid in TMAs is envisaged to remain the VOR/DME. GNSS may initially be used as supplemental navigation means in the TMAs. NDBs may continue to be used in TMAs on a case-by-case basis when there is an agreed requirement.

2.54 **En route.** VOR will continue to be the agreed en-route navigation aid in the AFI Region along conventional ATS routes. In case a requirement exists for a new route or for a higher level of navigation performance along an existing route, primary consideration should be given to meeting the requirement by the implementation of an RNAV route. NDBs will not normally be provided for en-route navigation unless there is an operational requirement which cannot be satisfied by any other means. GNSS will be used as a supplemental en-route navigation means and as the primary en-route means in designated airspace.

Surveillance — current status
and regional strategy

2.55 Since radar has not been a requirement in the region, the present surveillance system is characterized by very limited radar coverage in most of the FIRs. In fact, the surveillance system is mainly procedural-based, i.e. limited to pilot reports of position via HF communications, resulting in the application of large separation minima.

2.56 **Terminal areas.** Secondary surveillance radar (SSR) should be used within busy TMAs meeting criteria defined by APIRG. Primary radar may continue to be used in those TMAs where there is a mix of transponder-equipped and non-transponder-equipped aircraft and the number of non-transponder-equipped aircraft is sufficiently large to justify the requirement. ADS may be introduced, initially on a trial basis and eventually in broadcast mode (ADS-B) which is still under development.

2.57 **En-route.** En-route surveillance will mostly continue to be based on present procedural methods, but with improved pilot-controller communications in terms of reliability and transit times. This improvement will come about mostly as a result of enhanced mobile communications and of the fixed communications between adjacent ATS centres. Where a requirement for en-route surveillance has been identified, this shall rely essentially on SSR, and on ADS particularly for low-density, remote and oceanic airspace outside SSR coverage. There is no requirement for primary radar for en-route surveillance in the region. Those already in place should be progressively phased out.

European Air Navigation
Planning Group (EANPG)

2.58 The regional strategy for planning and implementation of CNS/ATM systems in the European Region is carried out by the European Air Navigation Planning Group (EANPG) through the management of the European Air Navigation Plan. This planning applies to a large number of States (49), covering an area which extends from the North Atlantic Region to the Asia/Pacific Regions.

2.59 The geographic characteristics and density of air traffic vary considerably across the region. For this reason, the Special European Regional Air Navigation Meeting (SP EUR RAN, Vienna, September 1994) agreed that, considering the complexity and diversity of the region, air navigation planning could best be achieved if it was organized in homogeneous areas of common requirements and interests, taking into account traffic density and the level of sophistication required.

2.60 For the above reasons, the western part of the region, an area of high traffic density, has seen its planning and implementation deeply influenced by the collective actions of States under the umbrella of the European Organisation for the Safety of Air Navigation (EUROCONTROL), whilst other States of the region (mainly States of the former Soviet Union) are assisted more directly by ICAO in their planning efforts. In addition, other State groupings such as the European Civil Aviation Conference (ECAC), the Joint Aviation Authorities (JAA) and others are also involved in air navigation planning, within their respective geographical coverage areas and under their own remits. However, coordination of planning activities is required by the EANPG in order to ensure that they all remain within the framework of the Global Plan, whilst respecting the integrity and compatibility of CNS/ATM systems among each other.

2.61 The ICAO European Regional planning machinery and the depth of its involvement in implementation and coordination aspects has evolved much further than required by the Chicago Convention. ICAO, at the regional level, has always provided a forum for States in which purely air navigation planning was combined with, and expanded to include, detailed implementation planning.

2.62 With respect to the remaining part of the region, work is in progress through the Group for Air Traffic Management in the Eastern part of the ICAO EUR Region, including Middle Asia (GATE) a subgroup of EANPG, to keep pace with developments and to ensure coherent planning and implementation of CNS/ATM systems, taking into account the interfaces between subregions and other ICAO regions.

2.63 Planning of a number of air navigation domains for the western part of the region was progressed through the European Air Traffic Control Harmonization and Integration Programme (EATCHIP) and its successor, the European Air Traffic Management Programme (EATMP), managed by EUROCONTROL. Details pertinent to the harmonization and integration process applicable to ECAC States are contained in the Convergence and Implementation (CIP) Document of EUROCONTROL. (Time lines indicated in the templates represent system implementation forecast information based on the CIP and/or information available to the Secretariat).

Air traffic management — current status and regional strategy

2.64 Present ATM systems in the European Region suffer shortcomings which include:

a) a non-effective use of EUR Region airspace, not sufficiently flexible and constrained by national boundaries;

b) in some areas of the EUR Region, and particularly in the "core area", despite efforts made by States through national measures and EATCHIP, ATC systems are reaching their capacity limits, causing an unacceptable number and level of delays;

c) in other parts of the EUR Region, although the need for more capacity is less acute throughout the region, the lack of a seamless approach to en-route and airport operations continues to prevent the optimization of resources;

d) lack of surveillance facilities mainly over large areas in the eastern part of the EUR Region;

e) dissimilar ATS procedures and separation standards causing flight information region (FIR) boundary changes to flight profiles;

f) the under-coordinated provision of present CNS systems resulting in duplication of resources and services;

g) poor-quality communications facilities and language difficulties in the eastern part of the region.

2.65 To overcome the present limitations and cope with growth, overall surveillance, appropriate ATS route structures and optimum flight profiles are required. Language difficulties and coordination procedure problems can be largely resolved by automated data processes. Efficient coordination between adjacent FIRs and common navigation standards and procedures are also essential to ensure that a transparent transfer of ATS responsibility is provided.

General remarks

2.66 As new CNS systems will provide for closer interaction between ground systems and airspace users before and during flight, improvements to ATM will permit a more flexible and efficient use of the airspace and will enhance traffic safety and regularity of flight. ATM may be viewed as the principal beneficiary of CNS improvements, i.e. it is the resultant benefits to ATM which constitute the rationale for incurring the costs of CNS improvements. In turn, improvements in ATM will ultimately benefit all airspace users.

2.67 The goals for the future ATM system can be summarized as follows:

a) maintenance of or increase in the existing level of safety;

b) increased system capacity and full utilization of capacity resources as required to meet traffic demand;

c) dynamic accommodation of user-preferred four-dimensional flight trajectories;

d) accommodation of full-range aircraft types and airborne capabilities;

e) improved provision of information to users, such as weather conditions, traffic situation and availability of facilities;

f) improved navigation and landing capabilities to support advanced approach and departure procedures;

g) increased user involvement in ATM decision-making including air-ground computer dialogue for flight negotiation;

h) creation, to the maximum extent possible, of a single continuum of airspace, where boundaries are transparent to users;

i) organization of airspace in accordance with ATM provisions and procedures;

j) minimization of airborne delays and holding, coupled with adjustment of flight-track schedules to achieve efficient traffic flows as well as efficient airspace and airport usage; and

k) improved ATS strategic planning to minimize future aircraft conflict and tactical conflict-resolution manoeuvring by the ATS system.

2.68 The following directions of change in ATM are envisaged in the European Region and are to be supported by future CNS systems:

a) improved handling and transfer of information between operators, aircraft and ATS units;

b) extended surveillance by using aircraft positions derived from airborne systems (i.e. automatic dependent surveillance);

c) advanced ground-based data processing systems, allowing for:

   1) the ability to take advantage of the navigation accuracy, in four dimensions, of modern aircraft;

   2) improved accommodation of user-preferred flight profiles in all phases of flight, based on the operator's objectives; and

   3) improvement in conflict detection and resolution, automated generation and transition of conflict-free clearances and rapid adaptation to changing traffic conditions;

These three aims of development, together with improved planning, will allow more dynamic airspace and ATM, particularly in high-density airspace.

2.69 A comprehensive assessment and analysis of the characteristics and the capabilities of the present system and of their implementation in various parts of the world ascertained that the shortcomings of the present CNS systems amount to essentially three factors:

a) the propagation limitations of current line-of-sight systems and/or accuracy and reliability limitations imposed by the variability of propagation characteristics of other systems;

b) the difficulty, caused by a variety of reasons, to implement present CNS systems and operate them in a consistent manner in large parts of the world; and

c) the limitations of voice communications and the lack of digital air-ground data interchange systems to support automated systems in the air and on the ground.

2.70 The limitations summarized in 2.69 are intrinsic to the systems themselves. Although their effects are not the same for every part of the world, it is evident that one or more of these factors inhibits the further development of air navigation almost everywhere. New CNS systems should surmount these limitations to allow ATM, on a global scale, to evolve and become more responsive to users' needs.

2.71 The present ground communications system, the aeronautical fixed telecommunication network (AFTN), is limited in throughput, data integrity, and the ability to handle bit-oriented message and data exchanges. The communications path will evolve to full aeronautical telecommunication network (ATN) capability through the deployment of ATN ground-ground routers. The ATN ground-ground router capability will be used to establish ATN routing domains. By implementing AFTN/ATN gateways over the ATN (bit-oriented) networks interconnected by ATN ground-ground routers, ground communications system resolves the shortcomings of AFTN, and will finally evolve into the ATS Message Handling System (AMHS). Some ground ATN networks are used for the ground portion of air-ground data interchange by deploying ATN air-ground router situated at the ground end of air-ground data link, connected to ground network and exclusively used for air-ground data interchanges.

2.72 On-going projects:

Project	**Organization**
ACAS — Airborne collision avoidance system	EUROCONTROL
RVSM — Reduced vertical separation minimum in Europe	ICAO EUR/NAT + EUROCONTROL
URD — ATM user requirement document	EUROCONTROL

Communications — current status and regional strategy

2.73 The European Region is characterized by the use of:

a) very high frequency (VHF) for voice and data communications in many continental and terminal areas; a shortage in the number of available VHF frequencies imposed the implementation of the EUROCONTROL "8.33 kHz Channel Spacing Project" in the so-called European core area;

b) data and voice communications for direct satellite/aircraft links in some parts of the region;

c) SSR Mode S data link, in the near future, in some parts of the region for air traffic services (ATS) purposes in some high-density airspace; and

d) ATN, in the future, for the interchange of digital data over dissimilar ground-to-ground and air-ground communication links between end systems.

2.74 The users of end systems include aircrew, air traffic controllers, aircraft operators, and others. The ATN, which is based on the International Organization for Standardization (ISO) open systems interconnection (OSI) reference model, will provide the inter-networking of aeronautical "subnetworks" in OSI terminology. User access to the ATN is via one or more subnetworks, which are connected by ATN routers. ATN routers may be either mobile (aircraft) or fixed (ground-based). The ATN router selects a path via aeronautical subnetworks based on user-specified communications parameters and subnetwork availability. This action is transparent to the end systems user who, therefore, does not need to know the area of coverage of particular subnetworks nor to change communications procedures depending upon the subnetworks in use.

2.75 An opportunity offered to enable early use of current technology by the application of ARINC Specification 622 over character-based data communications systems such as aircraft communications addressing and reporting system (ACARS) may provide for significant benefits in ATM. Several States are proceeding with implementation of ATS ground facilities that take early advantage of aircraft CNS packages, both of which are based on the ARINC Specification 622. The implementation plans recognize that eventual transition to the ATN is an objective and that ARINC Specification 622 is an interim step designed to gain early CNS/ATM benefits from existing technology.

General remarks

2.76 The European Region contains large expanses of sparsely populated, low traffic density continental area (Russian Federation) where the CNS systems which could be used are severely limited. Thus air-ground communications have been limited to high frequency (HF), often with the need for intermediate communicators. Surveillance has been limited to pilot reports of position via HF communications. These limitations have resulted in the large separations. For these reasons that area has been quick to embrace the new CNS/ATM systems, particularly controller-pilot data link communications (CPDLC) and automatic dependent surveillance (ADS).

2.77 On-going projects:

Project	**Organization**
ODIAC — Operational requirements for ATM air-ground data communications services	EUROCONTROL
Link 2000+ — Implementation of operational air-ground data link services in Europe (VDL Mode 2 and ATN)	EUROCONTROL
ASTERIX — All-purpose structured EUROCONTROL radar information exchange	EUROCONTROL
8.33 kHz — 8.33 kHz channel spacing	ICAO EUR/NAT + EUROCONTROL
PETAL II — Preliminary EUROCONTROL test of air-ground data link	EUROCONTROL
WACS — Wireless airport communications system	EUROCONTROL
MODE-S	EUROCONTROL

Navigation — current status
and regional strategy

2.78 The European Region is characterized by:

a) the progressive expansion of area navigation (RNAV) in conjunction with the ICAO required navigation performance (RNP) Standards; B-RNAV (RNP 5) was introduced starting in January 1998 in the entire ATS route network in the ECAC area;

b) in addition to RNAV and INS, the use of global navigation satellite system(s) (GNSS) for aircraft navigation;

c) WGS-84 implementation in large areas of the EUR Region; implementation in the whole area is ongoing;

d) the use of instrument landing systems (ILS) and a limited number of microwave landing systems (MLS) for approach and landing in accordance with the ICAO strategy; and

e) the progressive withdrawal of current navigation aids (NDB/VOR/DME) in use.

2.79 Aircraft are increasingly being equipped to utilize RNAV techniques, which is appropriate and inevitable because these techniques facilitate a flexible route system. Therefore, the future navigation system is based on the availability of airborne RNAV capability. The new concept called RNP has been developed to complement the RNAV system. RNP is broadly defined as the maximum deviation from assigned track within which the aircraft can be expected to remain with a given degree of probability. This concept eliminates the need for ICAO selection between competing navigation systems from the outset; however, it will not prevent ICAO from dealing with navigation techniques, which are in wide use internationally.

2.80 GNSS systems provide independent navigation, where the user performs on-board position determination from information received from broadcast transmissions by a number of satellites. GNSS provides highly reliable, highly accurate, high-integrity global coverage independently. Although the RNP concept allows for more than one satellite navigation system to be in use simultaneously, from an aircraft equipment point of view, maximum interoperability is essential as it would significantly simplify avionics and thereby reduce cost. It would also be attractive if satellite navigation systems could serve as complementary to and/or in a back-up role for each other.

2.81 On-going projects:

Project	**Organization**
WGS-84 — World geodetic system 1984	ICAO EUR/NAT + EUROCONTROL
B-RNAV — Basic RNAV	ICAO EUR/NAT + EUROCONTROL
P-RNAV — Precision RNAV	ICAO EUR/NAT + EUROCONTROL
EGNOS — European geostationary navigation overlay service	EU + others
GALILEO — European GNSS system	EU + others

Surveillance — current status and regional strategy

2.82 The European Region is characterized by:

a) the use of SSR Modes A and C and, in the near future, Mode S in some terminal and high-density continental airspace;

b) the use of ADS in some parts of the region; and

c) the diminishing use of primary radar.

2.83 Automatic dependent surveillance (ADS) is becoming available over the North Sea and continental airspace of the Russian Federation. SSR (augmented as necessary by Mode S) will continue to be used in terminal areas and in some high-density airspace. The use of primary radar will diminish.

2.84 The introduction of air-ground data links, together with sufficiently accurate and reliable aircraft navigation systems, presents the opportunity to provide surveillance services in areas which lack such services in the present infrastructure and in areas where the current systems prove difficult, uneconomical or even impossible, to implement. ADS is a function for use by ATS in which aircraft automatically transmit, via a data link, data derived from on-board navigation systems. As a minimum, the data should include the four-dimensional position. Additional data may be provided as appropriate. The ADS data would be used by the automated ATC system to present information to the controller. In addition to areas which are at present devoid of traffic position information other than pilot-provided position reports, ADS will find beneficial application in other areas, including high-density areas, where it may serve as an adjunct to and/or back-up for secondary surveillance radar and thereby reduce the need for primary radar. Also, in some circumstances, it may even substitute for secondary radar in the future. As with current surveillance systems, the full benefit of ADS requires supporting complementary two-way pilot-controller data and/or voice communications (voice for at least emergency and non-routine communications).

2.85 On-going projects:

Project	**Organization**
ARTAS — ATM surveillance tracker and server system	EUROCONTROL
MODE-S	ICAO EUR/NAT + EUROCONTROL
ADS — Automatic dependent surveillance	EUROCONTROL
ADS-B — Automatic dependent surveillance broadcast	Russian Federation

CNS systems evolution

2.86 The new CNS concept is very flexible in that each State has the choice of implementing specific system elements to meet its individual requirement for forming a complete, operable CNS/ATM system. Thus, the communications elements can be implemented using any or all combinations of satellite, VHF or SSR Mode S. States with high traffic density airspace would probably use all of these, but small States with continental airspace could implement the communications aspect of CNS/ATM and ADS using VHF alone.

CAR/SAM Regional Planning and Implementation Group (GREPECAS)

Air traffic management — current status and regional strategy

2.87 The tasks of planning the transition to CNS/ATM systems in the CAR/SAM Regions and developing a CNS/ATM Systems Implementation Plan were delegated to the new ATM/CNS Subgroup of the GREPECAS that has the responsibility of coordinating and harmonizing the work of the ATM and CNS Committees with regard to CNS/ATM matters.

2.88 In spite of the fact that much progress has been achieved, which has improved the provision of ATS in the CAR/SAM Regions since the Third CAR/SAM Regional Air Navigation Meeting (RAN CAR/SAM/3, Buenos Aires, 1999), there are still a number of significant deficiencies to overcome. These are expected to be solved through the implementation of ICAO CNS/ATM systems.

2.89 These deficiencies include the users' difficulties in utilizing the most optimum flight profiles in some areas of the CAR/SAM Regions, and the lack of ground system capacity to fully satisfy the users' needs and requirements.

2.90 Even though no persistent problems exist in the CAR/SAM Regions with regard to aircraft departure delays, on the basis of studies carried out by GREPECAS, some congested ATS routes and/or areas have been identified, especially during peak hours and/or during holiday periods. Likewise, there is a lack of flexibility in some parts of the airspace, which hinders accommodation of the users' needs, thereby under-utilizing the capacity of modern aircraft navigation systems.

2.91 The ATS route network in the CAR/SAM Regions should be improved through implementation of a greater number of RNAV routes, which would join pairs of cities with high volumes of traffic. Likewise, and due mainly to difficulties with the implementation of current surveillance systems, large areas exist that do not have the appropriate level of radar surveillance, especially over oceanic and remote airspace.

2.92 The regional strategy for the implementation of the CNS/ATM systems is being developed on the basis of the aforementioned deficiencies. The progressive evolution of ATM in the CAR/SAM Regions requires identifying homogeneous areas and associated air traffic flows. The ATM strategy and requirements would then be developed on the basis of such traffic flows. The timescales associated with these areas will therefore be refined over time. RNAV trials and demonstrations were initiated in two flows: Miami-Santiago and Miami-Rio de Janeiro/São Paulo.

Communications — current status and regional strategy

2.93 The CAR/SAM/3 RAN Meeting, in revising the air-ground communications requirements, formulated a new plan for the AM(R)S for voice and data communications considering ATN-compatible air-ground subnetworks such as VDL, HFDL and AMSS to meet digital data communications as per the CNS/ATM systems concept. In relation to voice communications, it should be noted that in certain areas VHF communications still suffer from coverage gaps and HF is used especially in oceanic and remote areas. However it should also be noted that HF communications services provided from some HF aeronautical stations need to be improved. Efforts are being made to eliminate as much as possible the HF and VHF voice communications deficiencies, and plans are being carried out to implement air-ground data links. In this regard FANS-1/A-equipped aircraft are being used to conduct CPDLC/ADS tests in order to gain pre-operational experience. Following the tendency of aviation industry developments, the implementation of VDL Mode 2 and ACARS over VDL Mode 2 (AOA) would be studied to support CPDLC applications. Tests on HFDL are being conducted.

2.94 In relation to ground-ground voice communications, plans in this respect formulated by the CAR/SAM/3 RAN Meeting show the tendency to implement voice communications using digital technology, and several digital networks integrating voice and data are operating or under development. In this regard continuous improvements are being made in relation to the elimination of voice communications problems associated with reliability and efficiency as well as the elimination of shortcomings from the air navigation plan. Plans for implementation of AIDC data communications are being studied.

2.95 The current AFTN meets operational requirements. The CAR/SAM/3 RAN Meeting developed new plans for message and data transmission. The current AFTN is being progressively improved by implementing AFTN/X.25 circuits and increasing the circuits' modulation rates. The implementation of digital networks would facilitate the introduction of highly reliable and efficient circuits to link AFTN communications centres as well as to deploy the regional ATN backbone. Plans for the implementation of the AMHS are being studied as the first ATN ground-ground application in order to initiate transition from the AFTN to the ATN internet services.

Navigation — current status
and regional strategy

2.96 The radio navigation services in the CAR/SAM Regions are currently being provided by conventional ground-based navigation aids and most of the required facilities have already been implemented. The non-directional radio beacons (NDBs) are gradually being replaced by VHF omnidirectional radio range (VORs) and UHF distance measuring equipment (DME). The instrument landing system (ILS), Cat I or Cat II, has been used at many airports of the regions for precision instrument approach and landing, and use of the microwave landing system (MLS) is not foreseen in the CAR/SAM Regions.

2.97 Based on the regional ATM evolution, the CAR/SAM Regions have a plan for the evolutionary introduction of the global navigation satellite system (GNSS), which includes the satellite-based augmentation system (SBAS) and ground-based augmentation system (GBAS). It was particularly noted that, according to the above-mentioned plan, with the gradual introduction of the GNSS, ground-based navigation aids are expected to be gradually withdrawn. The CAR/SAM Regions have made progress on GNSS implementation namely in the introduction of the use of GPS as a supplementary navigation means, anticipating in the near future its extension as a primary navigation system in oceanic and remote continental areas. A SBAS test based on the United States' wide area augmentation system (WAAS) is currently being carried out.

Surveillance — current status
and regional strategy

2.98 Surveillance is normally conducted by voice pilot reports and SSR/PSR facilities. These radar facilities provide services in most of the areas with dense air traffic. The CAR/SAM/3 RAN Meeting developed the first plan for surveillance facilities and services. SSR Modes A and C are being used, and plans for SSR Mode S are being considered for the long term. It is envisaged that the use of PSR will diminish. ADS is foreseen for oceanic and remote areas, especially in airspace with higher traffic flows.

North American Planning Group (NAMPG)

Air traffic management — current status
and regional strategy

2.99 The main limitations in Canada, Mexico and the United States are related to deficiencies in the infrastructure supporting the ATM parts of the subsystems. The most salient aspects of ATM limitations in the region are as follows:

a) obsolete ATS infrastructure in some cases;

b) deficiencies in the professional updating process of ATC personnel;

c) limited implementation of RNAV routes in the ATS route network;

d) communications systems shortcomings in some areas; and

e) limited or non-existent radar surveillance in some areas.

2.100 The evolution of ATM in Canada, Mexico and the United States has been planned on the basis of an integrated regional ATM system, considering that the most advantageous approach would be the implementation of CNS/ATM systems in defined homogeneous areas. The homogeneous areas within Canada, Mexico and the United States were defined considering the various degrees of complexity and diversity of the air navigation infrastructure, as well as the type of airspace in question. Consequently, the domestic airspace in Canada, Mexico and the United States has been defined as one homogeneous area, while the Gulf of Mexico airspace, because of its special characteristics, is defined as a separate homogeneous area. The implementation of air traffic flow management units in Canada and the United States has proven to be successful.

2.101 The Gulf of Mexico Work Group is investigating the possible near-term implementation of RNP 4 and RVSM in the Gulf of Mexico airspace. Three phases of a four-phase restructuring of the ATS route network in the Gulf of Mexico were completed in 1997, and the implementation of 10-minutes longitudinal separation minimum using the Mach number technique was implemented in 1996.

2.102 The CNS/ATM Plan being developed by the CAN/MEX/USA Working Group follows the guidance contained in the ICAO Global Plan, and implementation dates of the new CNS/ATM systems still require further coordination between the States involved.

Communications — current status
and regional strategy

2.103 VHF adequately covers air-ground communications over continental areas with the heaviest traffic density in Canada, Mexico and the United States. However, there is only partial VHF coverage, for the most part, in oceanic and remote continental areas, where air-ground communications tend to be based on HF systems.

2.104 There are new plans for the AMS for voice and data communications regarding ATN-compatible subnetworks such as VDL, HFDL and AMSS. Work is being carried out to implement air-ground data links such as VDL Mode 2 and ACARS over Mode 2 (AOA) implemented to support controller-pilot data link communications (CPDLC) applications. CPDLC will provide a second communications channel for use by pilots and controllers. It will augment the current voice communications capability, not replace it. Procedures on the flight deck and in the ATC unit will be developed to meet the demands of the new environment being created by implementation of HFDL.

2.105 Switched network systems and point-to-point links cover voice ground-to-ground communications (ATS speech circuits) for ATS coordination between ACC pairs. The ATN ground-ground subnetworks using the existing NADIN PSN and international network and its related applications have made progress from the test and development/validation phases to the current operational implementation. This testing will validate the AMHS system, the AFTN/AMHS Gateway, as well the ground-ground routers. Applications such as the AMHS have been identified as ATN applications that will offer significant operational benefits.

Navigation — current status
and regional strategy

2.106 En-route navigation rests basically on conventional radio aid systems. The regional ATS route network is, consequently, a system of fixed tracks whose very structure keeps it from adjusting to user needs. The present navigation system is a limiting factor for ATM and requires improvement both in terms of eliminating inadequate paths on some of its routes and implementing a larger number of fixed and random RNAV routes to link pairs of airports or TMAs with heavy traffic densities. This would make it possible to take advantage of both the RNAV capacity of the most modern aircraft and the new GNSS navigation methods connected with the RNP concept to achieve optimum traffic circulation with the consequent benefit to users.

2.107 Much progress has been made in GNSS planning and implementation, including the satellite-based augmentation system (SBAS) and ground-based augmentation system (GBAS); namely, in the introduction of the use of GPS as a supplementary navigation means, anticipating, in the near future, its extension as a primary navigation system in oceanic and remote continental areas. A massive GNSS approach implementation programme has been initiated by all three States and GNSS augmentation system agreements have been completed for the future expansion of the GNSS concept.

Surveillance — current status
and regional strategy

2.108 Recent years have seen substantial improvements in en-route surveillance, with the implementation and modernization of radar systems in a large part of the airspace of Canada, Mexico and the United States. Nevertheless, in several areas of the Gulf of Mexico and northern Canada, surveillance has been restricted to position reports sent by pilots via air-ground communications. These limitations have given rise to the less than optimum separation minima that are applied in these parts of the airspace, thereby limiting capacity and affecting efficiency.

2.109 With the introduction of air-ground data links, together with the availability of more accurate airborne navigation systems, all States agreed to move towards the implementation of automatic dependent surveillance (ADS) for oceanic or remote areas; however, further review is needed for continental domestic airspace areas.

North Atlantic Systems Planning Group
(NAT SPG)

Air traffic management — current status
and regional strategy

2.110 The major shortcomings affecting the vast majority of the region are the lack of real-time surveillance and direct controller-pilot communications, which severely limits airspace capacity and imposes significant constraints on aircraft flight profiles; meanwhile, aircraft movements are expected to at least double by the year 2010, as compared to 1988.

2.111 Two major axes dominate NAT traffic. First, there is the axis linking Europe (and the Middle East) to North America (excluding Alaska). Second, there is the axis linking the Eastern seaboard of North America with the Caribbean, South America and Bermuda. The major traffic flow between Europe and North America takes place in two distinct surges during each 24-hour period due to passenger preference, time zone differences and the imposition of night-time noise curfews at major airports.

2.112 Although a number of fixed tracks exist in the West Atlantic Route System (WATRS), the bulk of traffic operates on tracks that vary from day to day depending on meteorological conditions. The variability of the wind patterns would make a fixed-track system unnecessarily penalizing in terms of flight time and consequent fuel usage. Nevertheless, the volume of traffic along the core routes is such that a complete absence of any designated tracks (i.e. a free flow system) would be unworkable given the need to maintain procedural separation minima in airspace largely without radar surveillance.

General remarks

2.113 An initial concept was developed in 1992 and incorporated into the NAT Air Navigation Plan and Facilities and Services Implementation Document, by the Limited NAT Regional Air Navigation Meeting (Cascais, 3–18 November 1992). This concept has been refined taking into account the latest changes. These changes, however, have not affected the contents of the ANP. In general, the concept is benefit-driven and consists of logical and pragmatic sequences of phased changes from reduced vertical separation minimum, improved ATC flexibility to free flight. Technological and other requirements, such as safety analysis and cost-benefit studies, are mapped onto each change.

Communications — current status
and regional strategy

2.114 Current communications are via HF voice although VHF data links are being used for some applications, such as oceanic clearance delivery. The current HF network is saturated and it is difficult to obtain additional families. Because of this saturation, it is not always possible to provide the level of service requested by the users. The NAT concept uses controller-pilot data link communications (CPDLC) as the primary means of communications for routine communications. The concept is independent of the medium.

General remarks

2.115 Although the concept requires the aeronautical telecommunications network (ATN) as an end-state, provisions have been made to accommodate FANS 1/A. However, no decisions have been made regarding the level of service that will be provided to FANS 1/A-equipped aircraft.

Navigation — current status
and regional strategy

2.116 Aircraft operating in the minimum navigation performance specifications (MNPS) airspace must meet certain equipment requirements and must achieve a navigation performance of RNP 12.6 to sustain the current lateral separation minimum of 60 NM. Longitudinal separation is normally achieved by using the Mach number technique. Navigation performance in MNPS airspace is monitored to ensure that the risk in the system does not exceed the target level of safety (TLS). The concept requires improved navigation accuracy in order to maintain current separation minima let alone implementing reductions in horizontal separation.

Surveillance — current status
and regional strategy

2.117 Surveillance in most of the NAT Region, especially MNPS airspace, is via position reports delivered using HF voice through a third party at approximately every 10° of latitude. This does not permit ATC to detect gross navigation errors (GNE), the major contributing factor to the erosion of the TLS. Improved surveillance is a prerequisite to ensure the current safety levels are met, despite the expected doubling of traffic, as well as to sustain future reductions in horizontal separation. To achieve this, the concept specifies automatic dependent surveillance (ADS) over the ATN. Nevertheless, provisions are being made to accommodate FANS 1/A-equipped aircraft.

Chapter 3
STATISTICS

FORECASTS OF AIRCRAFT MOVEMENTS UP TO THE YEAR 2005

Factors affecting aircraft movements

3.1 The planning of aviation facilities and the development of aviation policies require assessment of future trends in aircraft movements as well as of passenger and freight traffic flows. This is becoming increasingly important because of concerns over airport and airspace congestion in some regions. Aircraft movements have grown quite rapidly for most of the past decade, increasing the pressure on airport and air traffic control facilities.

3.2 The primary factor affecting the number of aircraft movements is the demand for passenger travel. Passenger traffic forecasts are therefore key inputs to the aircraft movement forecasts.

3.3 When passenger demand increases, air carriers can respond by scheduling extra flights, by using larger aircraft, or by managing higher load factors. During the 1970s, air carriers accommodated most of the growth in demand by introducing larger aircraft. As a result of both increasing aircraft size and improving load factors, the growth in aircraft movements was quite small in the 1970s despite rapid growth in passenger traffic. From the early 1980s, the trend in average aircraft size has levelled out, and the growth rate in aircraft movements has approached the growth rate for passenger traffic. Past trends in average aircraft size and average load factor for total world scheduled services (excluding the Commonwealth of Independent States) are illustrated in Figure II-3-1.

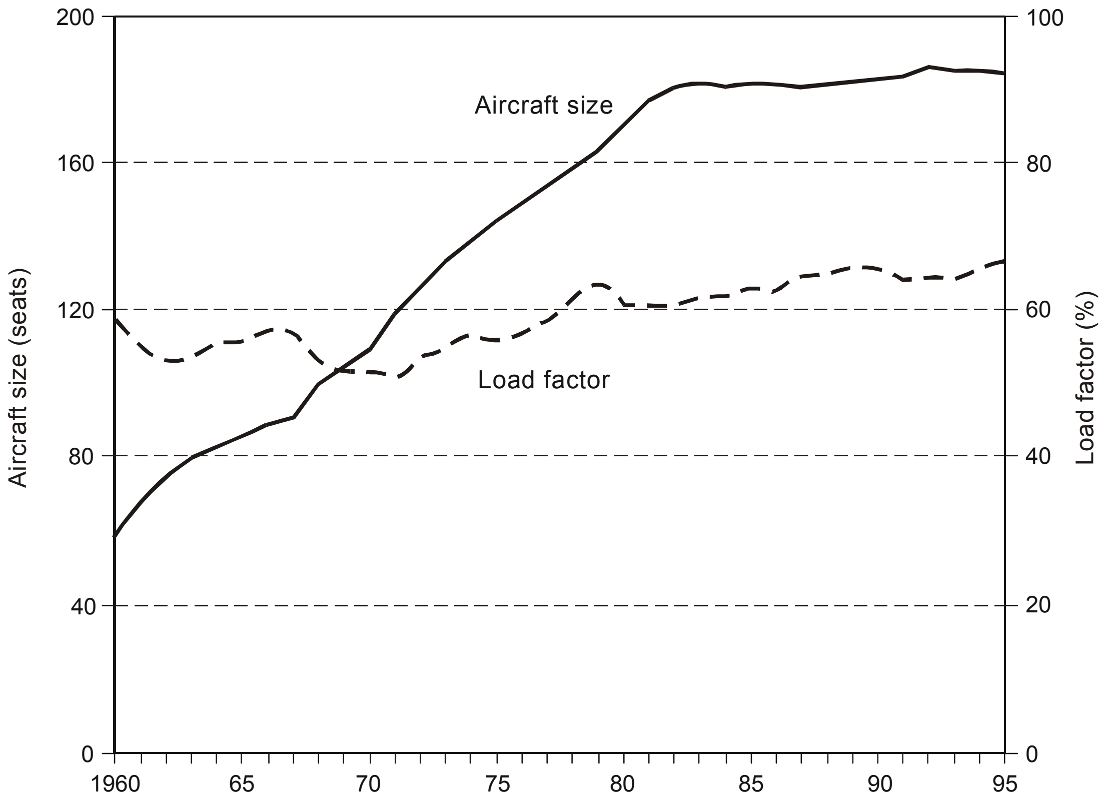
3.4 Gradual improvements in average load factors have resulted from marketing initiatives and yield management programmes, but there is evidence that the rate of improvement in load factors is slowing down. This is expected as the industry gradually approaches upper limits for load factors, which are partially determined by periodic and random variations in demand. Nevertheless, it is expected that the world average scheduled passenger load factor, which increased from 63 per cent in 1985 to 67 per cent in 1995, will rise to about 70 per cent by 2005.

3.5 The services provided by carriers to meet demand result from a large number of decisions concerning network structure, aircraft type and service frequency. These decisions depend on factors such as the availability of traffic rights, the characteristics of alternative aircraft, and consumer preferences and trade-offs between price and service quality. Despite the complexity of this process, it is possible to discern several key factors which are, in part, responsible for the observed change in the trend in average aircraft size and hence the relationship between traffic demand and aircraft movements.

3.6 The first of these factors is the trend towards liberalization or deregulation in some important markets. Deregulation in the United States domestic airline markets began in 1978, and the evolution of competitive strategies and market structures has continued since then. Adequate frequency and convenient interline and on-line connections, as well as low price, became important competitive tools. A more liberal regulatory environment also began to gradually emerge in other domestic markets and in international markets. The consequent increased priority given to frequency and direct service has tended to increase the number of aircraft movements required to satisfy a given level of demand.

3.7 The second factor is the arrival of new, mid-sized, high-technology aircraft. The 1970s saw B-747, DC-10 and L-1011 aircraft absorbed into airline fleets. These aircraft had favourable range and unit cost characteristics and were at the top end of the size spectrum. In contrast, the new aircraft of the 1980s, such as the B-757, B-767, MD-80 and A-310, were in the mid-size bracket. The economics of fleet replacement and expansion, therefore, encouraged a much smaller change in the average aircraft size during the 1980s than during the 1970s.

3.8 The North Atlantic is an example of a route group where, in recent years, regulatory developments and the characteristics of new aircraft types have encouraged the deployment of smaller aircraft. For example, extended range B-767 aircraft were able to service some secondary markets with direct transatlantic service after 1984. This resulted in a proliferation of direct transatlantic services between North America and Europe. The transpacific market also experienced an increase in the number of



Source.— ICAO Reporting Form A-1.
Note 1.— Excluding all-freight operations.
Note 2.— Excluding the Commonwealth of Independent States (CIS).

Figure II-3-1. Average aircraft size and load factor (passenger aircraft on scheduled services)

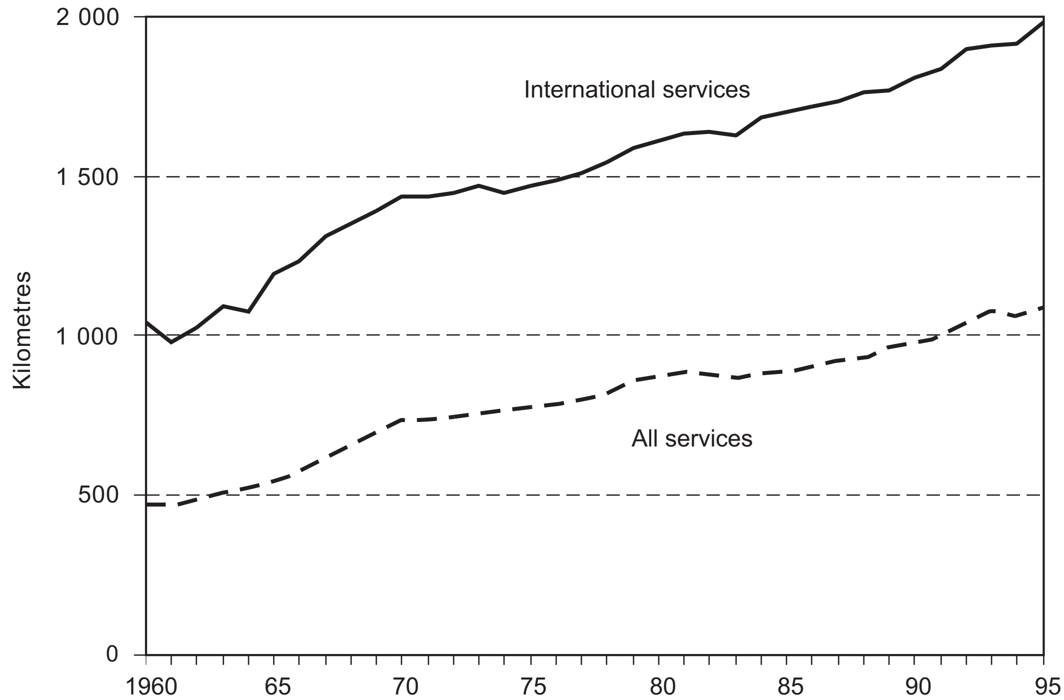
city-pairs with direct services, but the penetration of B-767 services was more limited than on the North Atlantic, with a correspondingly reduced impact on the trend.

3.9 The regulatory and technological factors described above are likely to continue. However, more liberal regulatory environment and competitive forces are encouraging consolidation and alliances among airlines that might eventually reduce or reverse the pressures to increase flight frequency at the expense of aircraft size. The build-up of airport and airspace congestion over the next decade is another factor that would favour larger aircraft. Furthermore, the new technology aircraft penetrating the fleets in the next decade include the B-777, A-330 and A-340, which are larger than the new aircraft of the 1980s. For these reasons, it is assumed that the world average aircraft size will begin to increase again and could reach almost 200 seats by 2005 compared with 184 seats in 1995.

Measures of aircraft movements

3.10 Aircraft movements can be measured in terms of the number of aircraft-kilometres (or aircraft hours) flown in the airspace or the number of aircraft departures from airports. While each measure is relevant for determining the demand for air traffic control facilities, aircraft departures are the key parameter for airport planning.

3.11 The link between the two measures is the average aircraft stage length. The trend in the average stage length is illustrated in Figure II-3-2. In the 1960s, average stage length for scheduled services increased by more than 4 per cent per annum, thus aircraft kilometres grew 4 to 5 per cent per annum faster than aircraft departures. In the past 20 years, the growth in average stage length has been around 1 or 2 per cent per annum. The increase in stage length reflects the changing pattern of demand, with growth



Source.— ICAO Reporting Form A-1.
Note.— Excluding the Commonwealth of Independent States (CIS).

Figure II-3-2. Average aircraft stage length (scheduled services)

in passenger and freight traffic being greater for long-haul routes than for short-haul routes. Another factor has been increases in the length-of-haul capabilities of new aircraft types progressively introduced into fleets. This was especially important in the 1960s with the introduction of jet aircraft. Over the forecast period (1995 to 2005), the average stage length is assumed to grow at about 2 per cent per annum.

Forecasting methodology

3.12 The forecasting process began with the forecasts of passenger traffic and incorporated assumptions for future load factors and aircraft size, which were together translated into forecasts of aircraft movements. The specification of the model used in this process is given in Appendix 2 of Circular 270.

3.13 The forecast in terms of global aircraft-kilometres was based on passenger-kilometre forecasts and assumptions from average passenger load factors and aircraft size (measured by number of seats). Since all-freight aircraft services account for less than 4 per cent of total services, their impact on the overall trend is very small. The forecast of global aircraft departures is derived from the forecast of aircraft-kilometres and expectations for the future trend in average aircraft stage length. The main assumptions for growth in world scheduled passenger traffic and trends in load factors, aircraft size and aircraft stage length over the period 1995 to 2005 are given below:

a) a growth in passenger-kilometres of 5.5 per cent per annum;

b) an increase in average load factor from 67 to 70 per cent;

c) a growth in average passenger aircraft size (in terms of seats) of 0.8 per cent per annum;

d) a growth in average aircraft stage length of 2.0 per cent per annum.

(Because of data constraints, all assumptions and forecasts exclude the Commonwealth of Independent States.)

Forecasts of world scheduled aircraft movements

3.14 The above analyses led to the forecast of average world annual growth rates of nearly 4.5 per cent for aircraft-kilometres and 2.5 per cent for aircraft departures over the period 1995 to 2005.

3.15 The growth rate for aircraft-kilometres is below the growth rate for passenger-kilometres by one percentage point per annum because of the increases in load factor and aircraft size. Growth in aircraft departures is below the growth in aircraft-kilometres by 2 per cent per annum, which is equal to the growth in stage length.

3.16 In Table II-3-1, the forecasts for aircraft movements are compared with actual past movements. The rates of growth reported in the table are average measures over the relevant 10-year periods; the rates over shorter periods may vary. Despite lower traffic growth, the growth in aircraft movements between 1985 and 1995 was relatively buoyant when compared with the growth between 1975 and 1985. This was a consequence of slower growth in average aircraft size and load factor.

3.17 Traffic growth in the 1980s placed increasing demands on the aviation infrastructure. Although there was an easing of demand pressures in the early 1990s, the forecasts imply an increase of about 55 per cent in aircraft-kilometres and 28 per cent in aircraft departures between 1995 and 2005. In absolute terms, the increase in aircraft-kilometres between 1995 and 2005 is expected to be only a little smaller than the increase that occurred between 1985 and 1995. The absolute increase in aircraft departures is forecast to be about 4.6 million between 1995 and 2005 compared with 4.8 million between 1985 and 1995. Overall increases of this magnitude could result in serious congestion of certain already hard-pressed airport and airspace facilities. It is important to recognize that in arriving at these forecasts, no allowance has been made for the effect that potential supply constraints might have on traffic volumes. In other words, if the supply of air traffic control and airport services does not keep pace with demand in the same way that it has in the past, then actual traffic flows may be suppressed below the levels of demand that are forecasted here.

SUMMARY OF ICAO AIR TRAFFIC FORECASTS FOR THE YEAR 2005

3.18 Tables II-3-2, II-3-3 and II-3-4 provide summaries of worldwide, regional and route-group forecasts, respectively.

Table II-3-1. ICAO scheduled aircraft movements* forecast for the year 2005

	Actual 1975	Actual 1985	Actual 1995	Forecast 2005	Average annual growth rate (per cent)		
					1975–1985	1985–1995	1995–2005
Aircraft-kilometres (millions)	7 516	10 598	18 279	28 400	3.5	5.6	4.5
Aircraft departures (thousands)	9 683	11 953	16 754	21 400	2.1	3.4	2.5

* Includes all-freight movements; excludes operations of aircraft registered in the Commonwealth of Independent States (CIS).

Table II-3-2. Summary of ICAO air traffic forecasts for the year 2005 (worldwide)

	Actual 1985	Actual 1995	Forecast 2005	Average annual growth rate (per cent)	
				1985–1995	1995–2005*
TOTAL SCHEDULED SERVICES					
Passenger-kilometres (billions)	1 367	2 228	3 807	5.0	5.5
Freight tonne-kilometres (millions)	39 797	83 082	163 950	7.6	7.0
Passengers carried (millions)	899	1 285	2 010	3.6	4.5
Freight tonnes carried (thousands)	13 742	21 488	34 600	4.6	5.0
Aircraft-kilometres (millions)**	10 598	18 279	28 400	5.6	4.5
Aircraft departures (thousands)**	11 953	16 754	21 400	3.4	2.5
INTERNATIONAL SCHEDULED SERVICES					
Passenger-kilometres (billions)	590	1 241	2 395	7.7	7.0
Freight tonne-kilometres (millions)	29 384	70 273	145 720	9.1	7.5
Passengers carried (millions)	194	373	680	6.8	6.0
Freight tonnes carried (thousands)	5 884	12 982	24 400	8.2	6.5

* Rounded to the nearest 0.5 percentage point.
** Excludes the Commonwealth of Independent States (CIS).

Table II-3-3. Summary of ICAO air traffic forecasts for the year 2005
(by region of airline registration)

	Actual 1985	Actual 1995	Forecast 2005	Average annual growth rate (per cent) 1985–1995	1995–2005*
TOTAL SCHEDULED SERVICES					
Passenger-kilometres (billions)					
Africa	36.7	51.0	77	3.3	4.0
Asia/Pacific	222.3	549.7	1 260	9.5	8.5
Europe	428.2	549.3	870	2.5	4.5
Middle East	42.7	67.0	115	4.6	5.5
North America	569.2	902.7	1 310	4.7	4.0
Latin America and the Caribbean	68.3	107.9	175	4.7	5.0
Freight tonne-kilometres (millions)					
Africa	1 163	1 418	2 050	2.0	4.0
Asia/Pacific	9 605	28 346	71 000	11.4	9.5
Europe	14 422	24 607	40 900	5.5	5.0
Middle East	1 880	3 775	6 800	7.2	6.0
North America	10 622	21 253	36 200	7.2	5.5
Latin America and the Caribbean	2 105	3 683	7 000	5.8	6.5
INTERNATIONAL SCHEDULED SERVICES					
Passenger-kilometres (billions)					
Africa	28.6	42.1	65	3.9	4.5
Asia/Pacific	150.2	372.9	870	9.5	9.0
Europe	202.7	426.8	735	7.7	5.5
Middle East	35.2	57.1	100	5.0	6.0
North America	125.3	271.7	495	8.0	6.0
Latin America and the Caribbean	36.5	70.3	130	6.8	6.5
Freight tonne-kilometres (millions)					
Africa	1 070	1 320	1 920	2.1	4.0
Asia/Pacific	8 589	26 243	66 900	11.8	10.0
Europe	11 589	23 815	40 000	7.5	5.5
Middle East	1 807	3 694	6 700	7.4	6.0
North America	4 842	12 162	24 000	9.6	7.0
Latin America and the Caribbean	1 487	3 039	6 200	7.4	7.5

*Rounded to the nearest 0.5 percentage point.

Table II-3-4. Summary of ICAO air traffic forecasts for the year 2005
(by international route group)

	Passengers carried (thousands)			Average annual growth rate (per cent)	
	Actual 1985	Actual 1995	Forecast 2005	1985–1995	1995–2005*
North Atlantic	20 964	38 100	59 168	6.2	4.5
Mid-Atlantic	1 471	2 570	4 186	5.7	5.0
South Atlantic	1 244	3 260	5 838	10.1	6.0
Transpacific	8 028	19 213	37 795	9.1	7.0
Between Europe and Asia/Pacific	5 870	20 400	42 045	13.3	7.5
Between Europe and Africa	9 280	11 000	14 783	1.7	3.0
Between Europe and Middle East	3 920	7 080	9 987	6.1	3.5
Between North America and South America	2 622	7 445	14 100	11.0	6.5
Between North America and Central America/Caribbean	15 562	24 684	38 333	4.7	4.5
Total above routes	68 961	133 752	226 237	6.8	5.5
Other routes	124 974	239 007	453 763	6.7	6.5
Total world	193 935	372 759	680 000	6.8	6.0

*Rounded to the nearest 0.5 percentage point.

Chapter 4

HOMOGENEOUS ATM AREAS AND MAJOR INTERNATIONAL TRAFFIC FLOWS

PLANNING PARAMETERS

4.1 The basis for development of a global, integrated ATM system is an agreed-to structure of homogeneous ATM areas and/or major international traffic flows. These areas and/or flows link together the various elements of the worldwide aviation infrastructure into a global system. The Global Plan lists several of these areas and/or traffic flows. Further updating and identification of these areas and/or traffic flows should be carried out by PIRGs in collaboration with the aircraft operators, reflecting the latter's requirements. "Feeder" routes may also have to be determined as part of the work effort toward identification of ATM requirements.

HOMOGENEOUS ATM AREA

4.2 In order to be consistent with worldwide growth and to support the economy of operations globally, requirements must be adapted to distinct areas with specific traffic flows. For this reason, the planning process for any particular region must begin with the identification of specific homogeneous ATM areas and/or major international traffic flows, based on user needs, followed by the development of an ATM plan for the region. See definition in 3.4 of Part I.

MAJOR TRAFFIC FLOWS

4.3 A major traffic flow is a concentration of significant volumes of air traffic on the same or proximate flight trajectories (see definition in 3.6 of Part I).

4.4 The basic planning parameter is the number of aircraft movements that must be provided with ATM services. Estimates and forecasts of annual aircraft movements over the planning period are required for high-level planning (Part II, Chapter 1 refers).

FORECASTS

4.5 Forecasts of aircraft movements in peak periods, such as during a particularly busy hour, are needed for detailed planning. Additionally, the establishment of major international traffic flows will require appropriate civil/military coordination and consideration of special use airspace (SUA) requirements. The coordination should take place during the planning stage so that major traffic flows will have a realistic chance of implementation. The principal data sources for current or historic aircraft movements are the official airline guides, i.e. World Airways Guide, ICAO's Traffic by Flight Stage Statistics and En-route Facility Statistics, and specific statistical information for flight information regions (FIRs), which can be obtained from relevant area control centres (ACCs).

4.6 The ICAO Secretariat, in cooperation with IATA, is progressively developing estimates of current traffic volumes for specific areas, which consist of major international route groups. This information is being designed to assist with planning at the global level. Additionally, traffic forecasting groups are being established by ICAO in order to provide the PIRGs with comprehensive databases and forecasts of traffic flows for groups of routes for the detailed planning process.

IDENTIFYING HOMOGENEOUS ATM AREAS AND MAJOR TRAFFIC FLOWS

4.7 Each regional planning group will develop its own work structure for accomplishing the work associated with the step-by-step approach identified in Chapter 3 of Part I. In some cases, an already established working group or CNS/ATM Subgroup may be in a suitable position to accomplish the work; in other cases, specific task forces or subgroups will need to be established.

4.8 To complete the work associated with the tables in this chapter, the following steps from the step-by-step approach will need to be considered:

Step 1. Identify homogeneous ATM areas and/or major traffic flows.

Step 2. List the ICAO region(s), flight information region(s) and State(s) involved in the homogeneous ATM areas and/or major international traffic flows.

Step 3. Carry out air traffic forecasts and ascertain airspace user needs.

Table II-4-1. Homogeneous ATM areas and major traffic flows/routing areas

Areas (AR)	*Homogeneous ATM areas and major traffic flows/routing areas*	*FIRs involved*	*Type of area covered*	*Remarks*
Africa-Indian Ocean (AFI) Region				
AR1	Europe — South America (EUR/SAM) (oceanic)	Canarias Casablanca Dakar Oceanic Recife Sal Oceanic	Oceanic low density	Major traffic flow EUR/SAM
AR2	Atlantic Ocean interface between the AFI, NAT and SAM Regions	Accra Dakar Johannesburg Oceanic Luanda Sal	Oceanic low density	Homogeneous ATM area AFI/NAT/SAM
AR3	Europe — Eastern Africa routes including the area of the Indian Ocean	Addis Ababa Antananarivo Asmara Cairo Dar es-Salaam Entebbe Khartoum Mauritius Mogadishu Nairobi Seychelles Tripoli	Continental/oceanic low density	Major traffic flow AFI/EUR
AR4	Europe to Southern Africa	Alger Brazzaville Gaborone Johannesburg Kano Kinshasa Luanda Lusaka N'Djamena Niamey Tunis	Continental low density	Major traffic flow AFI/EUR
AR5	Coastal routes over the Gulf of Guinea	Accra Brazzaville Dakar Kano Roberts	Continental low density	Homogeneous ATM area AFI
AR6	Iberian Peninsula to Canaries	Canarias Casablanca Lisbon	Oceanic high density	Major traffic flow AFI/EUR
AR7	North Africa coastal area	Alger Cairo Casablanca Tripoli Tunis	Continental/oceanic low density	Homogeneous ATM area AFI/EUR

Areas (AR)	*Homogeneous ATM areas and major traffic flows/routing areas*	*FIRs involved*	*Type of area covered*	*Remarks*
AR8	Continental Southern Africa	Beira Bloemfontein Cape Town Dar es-Salaam Durban Gaborone Harare Johannesburg Lilongwe Luanda Lusaka Port Elizabeth Windhoek	Continental low density	Homogeneous ATM area AFI
AR9	Trans-Sahelian	Asmara Dakar Kano Khartoum N'Djamena Niamey	Continental low density	Homogeneous ATM area AFI
AR10	Trans-Indian Ocean area interfacing with the ASIA/PAC Regions	Antananarivo Johannesburg Oceanic Mauritius Perth Seychelles	Oceanic high density	Homogeneous ATM area AFI/ASIA
Asia/Pacific (ASIA/PAC) Regions				
AR1	Asia/Australia and Africa	Bangkok, Bombay, Colombo, Jakarta, Kuala Lumpur, Madras, Malé, Melbourne, Singapore, Yangon, [and African FIR/UIRs]	Oceanic low density	Major traffic flow AFI/ASIA/MID
AR2	Asia (Indonesia north to China, Japan and the Republic of Korea), Australia/New Zealand	Auckland, Bali, Bangkok, Beijing, Biak, Brisbane, Guangzhou, Hanoi, Ho-Chi-Minh, Hong Kong, Honiara, Jakarta, Kota Kinabalu, Kuala Lumpur, Manila, Melbourne, Nadi, Naha, Nauru, Oakland, Phnom-Penh, Port Moresby, Shanghai, Singapore, Taegu, Taipei, Tokyo, Ujung Pandang, Vientiane, Wuhan, Yangon	Oceanic high density	Major traffic flow ASIA/PAC
AR3	Asia and Europe via north of the Himalayas	Almaty, Bangkok, Beijing, Guangzhou, Hanoi, Ho-Chi-Minh, Hong Kong, Kathmandu, Kunming, Lanzhou, Naha, Phnom-Penh, Pyongyang, Shanghai, Shenyang, Taegu, Taipei, Tokyo, Ulaanbaatar, Urumqi, Vientiane, Wuhan, Yangon, [and Russian Federation FIRs, and European FIRs]	Continental high density/continental low density	Major traffic flow ASIA/EUR/MID

Areas (AR)	*Homogeneous ATM areas and major traffic flows/routing areas*	*FIRs involved*	*Type of area covered*	*Remarks*
AR4	Asia and Europe via south of the Himalayas	Bali, Bangkok, Bombay, Calcutta, Colombo, Delhi, Dhaka, Hanoi, Ho-Chi-Minh, Hong Kong, Jakarta, Karachi, Kathmandu, Kota Kinabalu, Kuala Lumpur, Kunming, Lahore, Madras, Manila, Phnom-Penh, Singapore, Ujung Pandang, Vientiane, Yangon, [and Middle East/European FIR/UIRs]	Continental low density	Major traffic flow ASIA/EUR/MID
AR5	Asia and North America via the Russian Far East and the Polar Tracks via the Arctic Ocean and Siberia	Anchorage, Beijing, Canadian FIRs, Guangzhou, Hong Kong, Pyongyang, Russian Far East of 80E, Shanghai, Shenyang, Taegu, Tokyo, Wuhan and Ulaanbaatar	Continental low density/continental high density	Major traffic flow ASIA/EUR/NAM/NAT
AR6	Asia and North America (including Hawaii) via the Central and North Pacific	Anchorage, Hong Kong and Naha, Manila, Oakland (at and north of a line drawn by LAX-HNL-Guam-MNL), Taipei, Tokyo, Vancouver	Oceanic low density	Major traffic flow ASIA/NAM/PAC
AR7	New Zealand/Australia and South America	Auckland, Brisbane, Nadi, Tahiti, [and South America FIR/UIRs]	Oceanic low density	Major traffic flow ASIA/PAC/SAM
AR8	Australia/New Zealand, the South Pacific Islands and North America	Auckland, Brisbane and Port Moresby, Honiara, Nadi, Nauru, Oakland (southern region), Tahiti	Oceanic low density	Major traffic flow ASIA/NAM/PAC
AR9	South-East Asia and China, Republic of Korea, and Japan	Bali, Bangkok, Beijing, Guangzhou, Hanoi, Ho-Chi-Minh, Hong Kong, Jakarta, Kota Kinabalu, Kuala Lumpur, Kunming, Manila, Naha, Phnom-Penh, Pyongyang, Shanghai, Shenyang, Singapore, Taegu, Taipei, Tokyo, Ujung Pandang, Vientiane, Wuhan, Yangon	Oceanic high density	Major traffic flow ASIA
Caribbean/South American (CAR/SAM) Regions				
AR1	Buenos Aires — Santiago de Chile	Ezeiza, Mendoza, Santiago	Continental low density	SAM intra-regional major traffic flow
	Buenos Aires — São Paulo/Rio de Janeiro	Ezeiza, Montevideo, Curitiba, Brasilia	Continental low density	SAM intra-regional major traffic flow
	Santiago de Chile — São Paulo/Rio de Janeiro	Santiago, Mendoza, Cordoba, Resistencia, Asunción, Curitiba, Brasilia	Continental low density	SAM intra-regional major traffic flow
	São Paulo/Rio de Janeiro — Europe	Brasilia, Recife	Continental/oceanic low density	SAM/AFI/EUR inter-regional major traffic flow
AR2	São Paulo/Rio de Janeiro — Miami	Brasilia, Manaus, Maiquetía, Curaçao, Kingston, Santo Domingo, Port-au-Prince, Habana, Miami	Continental/oceanic low density	CAR/SAM/NAM inter- and intra-regional major traffic flow

Areas (AR)	*Homogeneous ATM areas and major traffic flows/routing areas*	*FIRs involved*	*Type of area covered*	*Remarks*
	São Paulo/Rio de Janeiro — New York	Brasilia, Belem, Paramaribo, Georgetown, Piarco, Rochambeau, San Juan (New York)	Continental/oceanic low density	CAR/SAM/NAM/NAT inter- and intra-regional major traffic flow
AR3	São Paulo/Rio de Janeiro — Lima	Brasilia, Curitiba, La Paz, Lima	Continental low density	SAM intra-regional major traffic flow
	São Paulo/Rio de Janeiro — Los Angeles	Brasilia, Porto Velho, Bogotá, Barranquilla, Panama, Central America, Mérida, México, Mazatlan (Los Angeles)	Continental low density	CAR/SAM/NAM inter- and intra-regional major traffic flow
	Mexico — North America	Mexico, Monterrey, Houston, Miami	Continental/oceanic low density	CAR/NAM inter-regional major traffic flow
AR4	Santiago — Lima — Miami	Santiago, Antofagasta, Lima, Guayaquil, Bogotá, Barranquilla, Panama, Kingston, Habana, Miami	Continental/oceanic low density	CAR/SAM/NAM inter- and intra-regional major traffic flow
	Buenos Aires — New York	Ezeiza, Resistencia, Asunción, La Paz, Porto Velho, Manaus, Maiquetía, Curaçao, Santo Domingo, Miami (New York)	Continental/oceanic low density	CAR/SAM/NAM/NAT inter- and intra-regional major traffic flow
	Buenos Aires — Miami	Ezeza, Resistencia, Cordoba, La Paz, Porto Velho, Bogotá, Barranquilla, Kingston, Habana, Miami	Continental/oceanic low density	CAR/SAM/NAM intra- and inter-regional major traffic flow
AR5	North of South America — Europe	Guayaquil, Bogotá, Maiquetía, Piarco (NAT-EUR)	Continental/oceanic low density	SAM/NAT/EUR inter-regional major traffic flow
AR6	Mexico — Europe	México, Mérida, Habana, Miami (NAT-EUR)	Continental/oceanic low density	CAR/NAM/NAT/EUR inter-regional major traffic flow
	Central America — Europe	Central America, Panama, Kingston, Port-au-Prince, Curaçao, Santo Domingo, San Juan (EUR)	Oceanic low density	CAR/NAT/EUR intra- and inter-regional major traffic flow
AR7	Santiago — Lima — Los Angeles	Santiago, Antofagasta, Lima, Guayaquil, Central America, Mérida, México, Mazatlan	Oceanic low density	CAR/SAM/NAM intra- and inter-regional major traffic flow
AR8	South America — South Africa	Ezeiza, Montevideo, Brasilia, Johannesburg (AFI)	Oceanic low density	SAM/AFI inter-regional major traffic flow
	Santiago de Chile — Easter Island — Papeete (PAC)	Santiago, Easter, Tahiti	Oceanic low density	SAM/PAC inter-regional major traffic flow
European (EUR) Region				
AR1	Within Western Europe	Wien, Bruxelles, Paris, Marseille, Reims, Bremen, Dusseldorf, Frankfurt, München, Milano, Genève, Zurich, London, Amsterdam	Continental very high density	Core area, homogeneous ATM area EUR
AR2	Western and Central Europe	ECAC States	Continental high density	Homogeneous ATM area

Areas (AR)	*Homogeneous ATM areas and major traffic flows/routing areas*	*FIRs involved*	*Type of area covered*	*Remarks*
AR2	Europe to North America	Europe (TBD), UK (London, Scottish), Ireland (Shannon), France (Paris, Reims, Brest)	Continental high density	Major traffic flow linking Europe to North America via North Atlantic
AR3	Western Europe to Far East Asia via trans-polar transit routes	Core Area, Norway (Bodø, Oslo, Stavenger, Trondheim), Finland (Tampere, Rovaniemi), Russian Federation (TBD), Japan	Continental high density/continental low density	Major traffic flow via ATS route A333 and all routes north of it
AR4	Western Europe to Far East Asia via trans-Siberian transit routes	Core Area, Poland (Warszawa), Baltic States (Tallinn, Riga, Vilnius), Finland (Tampere, Rovaniemi), Russian Federation (TBD), Japan	Continental high density/continental low density	Major traffic flow via ATS routes south of A333 (excluding), up to and including the ATS route R211
AR5	North America to Eastern Europe and Asia via cross-polar transit routes	Denmark (Søndrestrøm), Russian Federation (TBD), USA, Canada, Mongolia, China	Continental low density/oceanic low density	Major traffic flow via ATS routes linking North America with Eastern Europe and Asia through the airspace of the Russian Federation east of the ATS routes G476 and A74 up to the ATS route A218 (excluding)
AR6	North America to Southeast Asia via trans-eastern transit routes	Russian Federation (TBD), USA, Canada, China	Continental low density/oceanic low density	Major traffic flow via ATS routes linking North America with Southeast Asia through the airspace of the Russian Federation including ATS route A218 and all routes east of it
AR7	Europe to Central and Southeast Asia via trans-Asian transit routes	Baltic States (Tallinn, Riga, Vilnius), Finland (Tampere, Rovaniemi), Kazakhstan (TBD), Russian Federation (TBD), Mongolia, China	Continental low density	Major traffic flow via ATS routes linking European States with Central and Southeast Asia, aligned south of ATS routes B159, A222, B200 and A310, including ATS route G3
AR8	Europe to Middle Asia via Asian transit routes	Ukraine (TBD), Turkmenistan (TBD), Kazakhstan (TBD), Turkey, Armenia (Yerevan), Georgia (Tbilisi, Sukhumi), Azerbaijan (Baku), Uzbekistan (Samarkand, Tashkent, Nukus), Russian Federation (TBD), Iran, Afghanistan	Continental low density	Major traffic flow via ATS routes linking European States with Middle Asia, south of ATS route G3
ARx	Western/Central Europe — Asia (trans-Siberia)	(to be developed)	Continental low density/continental high density	Major traffic flow ASIA/EUR/MID
ARx	Eastern Europe — Middle Asia	(to be developed)	Continental low density	Major traffic flow ASIA/EUR/MID
ARx	Europe — Central Asia/Pacific	(to be developed)	Continental low density	Major traffic flow ASIA/EUR/MID/PAC
ARx	Western Europe — Eastern Europe	(to be developed)	Continental low density/continental high density	Homogeneous ATM area EUR

Areas (AR)	*Homogeneous ATM areas and major traffic flows/routing areas*	*FIRs involved*	*Type of area covered*	*Remarks*
North Atlantic (NAT) Region				
ARx	North America — Western/Central Europe	Bodø, Gander, New York, Reykjavik, Santa Maria, Shanwick, Søndrestrøm	Oceanic high density/continental high density	Major traffic flow EUR/NAM/NAT MNPS airspace
ARx	North America — Caribbean	New York	Oceanic high density	Major traffic flow West Atlantic route system
Middle East (MID) Region				
AR1	Asia and Europe, Asia and the Middle East, Europe and the Middle East, via the northern Arabian Peninsula and Eastern Mediterranean	Amman, Baghdad, Bahrain, Beirut, Cairo, Damascus, Emirates, Jeddah, Kuwait, Muscat, Tel Aviv	Continental high density	Mainly intra-regional and MID to/from ASIA and EUR. Some overflying EUR/ASIA traffic
AR2	Egypt and the southern Arabian Peninsula to/from Europe, Africa and Asia	Cairo, Bahrain, Emirates, Jeddah, Muscat, Sana'a	Remote continental and oceanic low density (but seasonally high density)	Major traffic flow Mainly landing and departing the MID region. Some EUR/AFI traffic. Seasonal pilgrim flights to and from Africa, Central, South and South-East Asia
AR3	Asia and Europe, Asia and the Middle East, Europe and the Middle East, north of the Gulf	Teheran, Kabul	Continental high density	Major traffic flow ASIA/EUR
North America (NAM) Region				
NA-14	North America/ polar tracks	Domestic US FIRs (Chicago, Seattle, Cleveland, New York, Boston, Minneapolis, Salt Lake), Canadian FIRs (Montreal, Toronto, Winnipeg, Edmonton, Vancouver), Anchorage, Beijing, Guangzhou, Hong Kong, Pyongyang, Russian Far East FIRs, Shanghai, Shenyang, Taegu, Tokyo, Wuhan, and Ulaanbaatar	Continental/oceanic low density Major traffic flow	One-directional flow ASIA/EUR/NAM/NAT
NA-15	Toronto — Cleveland, Chicago	Toronto, Cleveland, Chicago	Continental high density Major traffic flow	CAN-US East-west route
	Toronto — New York, Philadelphia, Washington	Toronto, Cleveland, New York, Washington	Continental high density Major traffic flow	CAN-US North-south route
	Montreal — New York	Montreal, Boston, New York	Continental high density Major traffic flow	CAN-US North-south route
	Anchorage, Vancouver — Seattle — San Francisco — Los Angeles	Anchorage, Vancouver, Seattle, Oakland, Los Angeles	Continental high density Major traffic flow	CAN-US North-south route

Areas (AR)	*Homogeneous ATM areas and major traffic flows/routing areas*	*FIRs involved*	*Type of area covered*	*Remarks*
NA-16 Canada East-west flows	Toronto — Winnipeg — Calgary — Regina — Vancouver	Winnipeg, Edmonton, Vancouver	Continental high density Major traffic flow	Major traffic flows in Canadian southern domestic airspace
	Toronto — Ottawa — Montreal — Halifax	Toronto, Montreal, Moncton		
	Vancouver — Edmonton	Vancouver, Edmonton		
	Edmonton — Calgary	Edmonton		
	Winnipeg — Regina	Winnipeg		
NA-17 US East-west flows	Boston/New York/Chicago — Seattle	Boston, New York, Cleveland, Indianapolis, Chicago, Minneapolis, Salt Lake, Seattle	Continental high density Major traffic flow	Major traffic flows in domestic US airspace
	Boston/New York/Washington DC/Denver — San Francisco	Boston, New York, Cleveland, Indianapolis, Chicago, Kansas City, Salt Lake, Oakland		
	Boston/New York/Washington DC/Denver — Los Angeles	Boston, New York, Cleveland, Indianapolis, Chicago, Kansas City, Albuquerque, Los Angeles		
	Atlanta/Dallas/ Phoenix — Los Angeles	Atlanta, Memphis, Fort Worth, Albuquerque, Los Angeles		
NA-17 US East-west flows	Atlanta/Dallas/ Phoenix — San Diego	Atlanta, Memphis, Fort Worth, Albuquerque, Los Angeles		
	Miami/Houston/ Dallas/Phoenix — San Diego	Miami, Houston, Fort Worth, Albuquerque, Los Angeles		
	Miami/Houston/ Dallas/Phoenix — Los Angeles	Miami, Houston, Dallas, Albuquerque, Los Angeles		
GM-1	Mexico — North America	Mexico, Houston, Miami; Mexico, Albuquerque; Mexico, Los Angeles	Continental/oceanic low density Major traffic flow	CAR/NAM inter-regional traffic flow
GM-2	Mexico — Europe	Mexico, Havana, Miami (NAT-EUR)	Continental/oceanic low density Major traffic flow	CAR/NAM/NAT/EUR inter-regional traffic flow

Chapter 5

AIR TRAFFIC MANAGEMENT

INTRODUCTION

5.1 The material contained in this chapter complements that contained in Chapter 4 of Part I and in the ATM sections of the FASIDs of the regional ANPs. This chapter is kept under review by the PIRGs and should be periodically updated to reflect the information contained in the ATM sections of the regional FASIDs.

ATM OBJECTIVES

5.2 Each regional planning group will develop its own work structure for accomplishing the work associated with the step-by-step approach identified in Chapter 3 of Part I. In some cases, an already established working group or CNS/ATM Subgroup may be in a suitable position to accomplish the work; in other cases, specific task forces or subgroups will need to be established.

5.3 To complete the tables in this chapter, the following steps from the global planning methodology outlined in Chapter 3 of Part I will need to be considered:

Step 4. Perform an operational analysis of the current infrastructure for the areas identified in terms of:

a) ATM limitations and shortcomings;

b) separation standards; and

c) CNS availability.

Step 5. Determine the ATM objectives for the areas identified in Step 2 using as the basis the guidance material contained in the operational concept document (operational analysis) (Appendices A and B to Chapter 4 of Part I refer).

GLOBAL AIR TRAFFIC MANAGEMENT SYSTEM IMPLEMENTATION OBJECTIVES BY REGION

		GLOBAL AIR TRAFFIC MANAGEMENT SYSTEM IMPLEMENTATION BY REGION																
			1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Development of SARPs	**RTSP**	Global ATM					■	■	■	■	■	■	■	■					
		Functional integration of flight OPS/ATM					■	■	■	■	■	■	■	■					
		ATM requirements for CNS				■	■	■	■	■	■								
		Separation between aircraft					■	■	■	■	■	■	■	■	■	■	■	■	■
		AIDC						■	■	■	■								
		ATFM procedures and systems								■	■	■	■	■					
Aircraft equipage/ flight operations		RNP certification/approval					■	■	■	■	■	■	■	■	■	■	■	■	■
		Functional integration of airborne systems with ground systems													■	■	■	■	■
Implementation and operational use																			
REGIONAL ATM OPERATIONAL CONCEPT																			
Global		Determination of major traffic flows				■	■												
Regions		AFI	■	■	■	■	■												
		ASIA/PAC				■	■												
		CAR/SAM				■	■	■	■										
		EUR	■	■	■	■	■	■	■										
		MID				■	■	■	■										
		NAM[1]																	
		NAT	■																
Global		Identification of ATM objectives based on these traffic flows					■	■											
Regions		AFI	■	■	■	■	■												
		ASIA/PAC				■	■												
		CAR/SAM				■	■	■	■										
		EUR						■	■	■									
		MID				■	■	■	■										
		NAM[1]																	
		NAT	■	■	■														
Global		Development of regional strategic airspace CNS infrastructure plan based on ATM requirements							■	■									
Regions		AFI	■	■	■	■	■												
		ASIA/PAC				■	■												
		CAR/SAM				■	■	■	■										
		EUR						■	■	■									
		MID				■	■	■	■	■									
		NAM[1]																	
		NAT	■	■	■														

1. To be developed

	GLOBAL AIR TRAFFIC MANAGEMENT SYSTEM IMPLEMENTATION BY REGION																	
		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
AIRSPACE MANAGEMENT																		
Global	Optimized sectorization								■	■	■	■	■	■	■	■	■	■
Regions	AFI							■	■	■	■	■	■	■	■	■	■	■
	ASIA/PAC					■	■	■	■	■	■	■	■	■	■	■	■	■
	CAR/SAM							■	■	■	■	■	■	■	■	■	■	■
	EUR					■	■	■	■	■	■	■	■	■	■	■	■	■
	MID							■	■	■	■	■	■	■	■	■	■	■
	NAM					■	■	■	■	■	■	■	■	■	■	■	■	■
	NAT[1]																	
Global	Fixed RNAV ATS routes				■	■	■	■	■	■	■	■	■	■	■	■	■	■
Regions	AFI	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	ASIA/PAC	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	CAR/SAM	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	EUR					■	■	■	■	■	■							
	MID				■	■	■	■	■	■	■	■	■	■	■	■	■	■
	NAM			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	NAT	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Global	Contingency RNAV routes						■	■	■	■	■	■	■	■	■	■	■	■
Regions	AFI								■	■	■	■	■	■	■	■	■	■
	ASIA/PAC		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	CAR/SAM[1]																	
	EUR					■	■	■	■	■	■							
	MID				■	■	■	■	■	■	■	■	■	■	■	■	■	■
	NAM[1]																	
	NAT[1]																	
Global	Random RNAV routes											■	■	■	■	■	■	■
Regions	AFI		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	ASIA/PAC			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	CAR/SAM											■	■	■	■	■	■	■
	EUR											■	■	■	■	■	■	■
	MID[1]																	
	NAM[1]																	
	NAT[1]																	

1. To be developed

	GLOBAL AIR TRAFFIC MANAGEMENT SYSTEM IMPLEMENTATION BY REGION																	
		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Global	Airspace desegregation/flexible use of airspace[2]								■	■	■	■	■	■	■	■	■	■
Regions	AFI				■	■	■	■	■	■	■	■	■	■	■	■	■	■
	ASIA/PAC								■	■	■	■	■	■	■	■	■	■
	CAR/SAM[1]																	
	EUR				■	■	■	■	■	■	■	■	■	■	■	■	■	■
	MID								■	■	■	■	■	■	■	■	■	■
	NAM			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	NAT[1]																	
Global	Application of RNP					■	■	■	■	■	■	■	■	■	■	■	■	■
Regions	AFI					■	■	■	■	■	■	■	■	■	■	■	■	■
	ASIA/PAC			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	CAR/SAM								■	■	■	■	■	■	■	■	■	■
	EUR				■	■	■	■	■	■	■	■	■	■	■	■	■	■
	MID								■	■	■	■	■	■	■	■	■	■
	NAM						■	■	■	■	■	■	■	■	■	■	■	■
	NAT	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Global	Application of RCP[2]											■	■	■	■	■	■	■
Regions	AFI[1]																	
	ASIA/PAC[1]																	
	CAR/SAM[1]																	
	EUR[1]																	
	MID[1]																	
	NAM[1]																	
	NAT[1]																	
Global	Application of RSP[2]													■	■	■	■	■
Regions	AFI[1]																	
	ASIA/PAC[1]																	
	CAR/SAM[1]																	
	EUR[1]																	
	MID[1]																	
	NAM[1]																	
	NAT[1]																	

1. To be developed.
2. Emerging concept or technology — consensus still to be reached.

	GLOBAL AIR TRAFFIC MANAGEMENT SYSTEM IMPLEMENTATION BY REGION																	
		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
AIR TRAFFIC SERVICES																		
Global	Trajectory conformance monitoring						■	■	■	■	■	■	■	■	■	■	■	■
Regions	AFI											■	■	■	■	■	■	■
	ASIA/PAC					■	■	■	■	■	■	■	■	■	■	■	■	■
	CAR/SAM[1]																	
	EUR								■	■	■	■	■	■	■	■	■	■
	MID				■	■	■	■	■	■	■	■	■	■	■	■	■	■
	NAM[1]																	
	NAT						■	■	■	■	■	■	■	■	■	■	■	■
Global	Minimum safe altitude warning					■	■	■	■	■	■	■	■	■	■	■	■	■
Regions	AFI								■	■	■	■	■	■	■	■	■	■
	ASIA/PAC	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	CAR/SAM				■	■	■	■	■	■	■	■	■	■	■	■	■	■
	EUR					■	■	■	■	■	■	■	■	■	■	■	■	■
	MID							■	■	■	■	■	■	■	■	■	■	■
	NAM						■	■	■	■	■	■	■	■	■	■	■	■
	NAT[1]																	
Global	Conflict prediction						■	■	■	■	■	■	■	■	■	■	■	■
Regions	AFI								■	■	■	■	■	■	■	■	■	■
	ASIA/PAC		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	CAR/SAM[1]																	
	EUR						■	■	■	■	■	■	■	■	■	■	■	■
	MID					■	■	■	■	■	■	■	■	■	■	■	■	■
	NAM	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	NAT	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Global	Conflict alert		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Regions	AFI									■	■	■	■	■	■	■	■	■
	ASIA/PAC		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	CAR/SAM[1]																	
	EUR						■	■	■	■	■	■	■	■	■	■	■	■
	MID								■	■	■	■	■	■	■	■	■	■
	NAM							■	■	■	■	■	■	■	■	■	■	■
	NAT	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Global	Conflict resolution advice[2]									■	■	■	■	■	■	■	■	■
Regions	AFI											■	■	■	■	■	■	■
	ASIA/PAC					■	■	■	■	■	■	■	■	■	■	■	■	■
	CAR/SAM[1]																	
	EUR[1]																	
	MID										■	■	■	■	■	■	■	■
	NAM[1]																	
	NAT								■	■	■	■	■	■	■	■	■	■

1. To be developed.
2. Emerging concept or technology — consensus still to be reached.

	GLOBAL AIR TRAFFIC MANAGEMENT SYSTEM IMPLEMENTATION BY REGION																	
		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Global	Functional integration of ground systems with airborne systems													■	■	■	■	■
Regions	AFI[1]																	
	ASIA/PAC[1]																	
	CAR/SAM[1]																	
	EUR[1]																	
	MID[1]																	
	NAM[1]																	
	NAT[1]																	
Global	Dynamic accommodation of user-preferred flight profiles[2]										■	■	■	■	■	■	■	■
Regions	AFI									■	■	■	■	■	■	■	■	■
	ASIA/PAC						■	■	■	■	■	■	■	■	■	■	■	■
	CAR/SAM[1]																	
	EUR								■	■	■	■	■	■	■	■	■	■
	MID[1]																	
	NAM						■	■	■	■	■	■	■	■	■	■	■	■
	NAT[1]																	
Global	Reduced vertical separation				■	■	■	■	■	■	■	■	■	■	■	■	■	■
Regions	AFI										■	■	■	■	■	■	■	■
	ASIA/PAC							■	■	■	■	■	■	■	■	■	■	■
	CAR/SAM									■	■	■	■	■	■	■	■	■
	EUR								■	■	■	■	■	■	■	■	■	■
	MID										■	■	■	■	■	■	■	■
	NAM				■	■	■	■	■	■	■	■	■	■	■	■	■	■
	NAT				■	■	■	■	■	■	■	■	■	■	■	■	■	■
Global	Reduced longitudinal separation				■	■	■	■	■	■	■	■	■	■	■	■	■	■
Regions	AFI					■	■	■	■	■	■	■	■	■	■	■	■	■
	ASIA/PAC			■	■	■	■	■	■	■	■	■	■	■	■	■		
	CAR/SAM							■	■	■	■	■	■	■	■	■	■	■
	EUR					■	■	■	■	■	■	■	■	■	■	■	■	■
	MID						■	■	■	■	■	■	■	■	■	■	■	■
	NAM						■	■	■	■	■	■	■	■	■	■	■	■
	NAT[1]																	
Global	Reduced lateral separation				■	■	■	■	■	■	■	■	■	■	■	■	■	■
Regions	AFI					■	■	■	■	■	■	■	■	■	■	■	■	■
	ASIA/PAC			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	CAR/SAM										■	■	■	■	■	■	■	■
	EUR						■	■	■	■	■	■	■	■	■	■	■	■
	MID								■	■	■	■	■	■	■	■	■	■
	NAM							■	■	■	■	■	■	■	■	■	■	■
	NAT[1]																	

1. To be developed.
2. Emerging concept or technology — consensus still to be reached.

	GLOBAL AIR TRAFFIC MANAGEMENT SYSTEM IMPLEMENTATION BY REGION																	
		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Global	Independent IFR approaches to closely spaced runways			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Regions	AFI[1]																	
	ASIA/PAC				■	■	■	■	■	■	■	■	■	■	■	■	■	■
	CAR/SAM[1]																	
	EUR			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	MID[1]																	
	NAM[1]																	
	NAT[1]																	
Global	RNAV SIDs and STARs						■	■	■	■	■	■	■	■	■	■	■	■
Regions	AFI										■	■	■	■	■	■	■	■
	ASIA/PAC					■	■	■	■	■	■	■	■	■	■	■	■	■
	CAR/SAM									■	■	■	■	■	■	■	■	■
	EUR								■	■	■	■	■	■	■	■	■	■
	MID								■	■	■	■	■	■	■	■	■	■
	NAM[1]																	
	NAT[1]																	
Global	Curved and segmented approaches						■	■	■	■	■	■	■	■	■	■	■	■
Regions	AFI[1]																	
	ASIA/PAC[1]																	
	CAR/SAM[1]																	
	EUR[1]																	
	MID[1]																	
	NAM[1]																	
	NAT[1]																	
Global	Arrival metering, sequencing and spacing[2]									■	■	■	■	■	■	■	■	■
Regions	AFI[1]																	
	ASIA/PAC[1]																	
	CAR/SAM[1]																	
	EUR								■	■	■	■	■	■	■	■	■	■
	MID[1]																	
	NAM[1]																	
	NAT[1]																	
Global	A-SMGCS[2]									■	■	■	■	■	■	■	■	■
Regions	AFI[1]																	
	ASIA/PAC[1]																	
	CAR/SAM[1]																	
	EUR								■	■	■	■	■	■	■	■	■	■
	MID[1]																	
	NAM[1]																	
	NAT[1]																	

1. To be developed.
2. Emerging concept or technology — consensus still to be reached.

	GLOBAL AIR TRAFFIC MANAGEMENT SYSTEM IMPLEMENTATION BY REGION																	
		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Global	ATS inter-facility data (AIDC) communications									■	■	■	■	■	■	■	■	■
Regions	AFI							■	■	■	■	■	■	■	■	■	■	■
	ASIA/PAC					■	■	■	■	■	■	■	■	■	■	■	■	■
	CAR/SAM										■	■	■	■	■	■	■	■
	EUR	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	MID									■	■	■	■	■	■	■	■	■
	NAM				■	■	■	■	■	■	■	■	■	■	■	■	■	■
	NAT	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Global	Application of data link				■	■	■	■	■	■	■	■	■	■	■	■	■	■
Regions	AFI					■	■	■	■	■	■	■	■	■	■	■	■	■
	ASIA/PAC		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	CAR/SAM									■	■	■	■	■	■	■	■	■
	EUR	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	MID									■	■	■	■	■	■	■	■	■
	NAM			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	NAT	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
AIR TRAFFIC FLOW MANAGEMENT																		
Global	Centralized ATFM				■	■	■	■	■	■	■	■	■	■	■	■	■	■
Regions	AFI[1]																	
	ASIA/PAC[1]																	
	CAR/SAM[1]																	
	EUR			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	MID[1]																	
	NAM[1]																	
	NAT[1]																	
Global	Inter-regional cooperative ATFM												■	■	■	■	■	■
Regions	AFI[1]																	
	ASIA/PAC[1]																	
	CAR/SAM[1]																	
	EUR[1]																	
	MID[1]																	
	NAM[1]																	
	NAT[1]																	
Global	Establishment of ATFM databases					■	■	■	■	■	■	■	■	■	■	■	■	■
Regions	AFI[1]																	
	ASIA/PAC[1]																	
	CAR/SAM[1]																	
	EUR					■	■	■	■	■	■	■	■	■	■	■	■	■
	MID[1]																	
	NAM							■	■	■	■	■	■	■	■	■	■	■
	NAT							■	■	■	■	■	■	■	■	■	■	■

1. To be developed

	GLOBAL AIR TRAFFIC MANAGEMENT SYSTEM IMPLEMENTATION BY REGION																	
		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Global	Application of strategic ATFM planning						■	■	■	■	■	■	■	■	■	■	■	■
Regions	AFI[1]																	
	ASIA/PAC[1]																	
	CAR/SAM[1]																	
	EUR	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	MID[1]																	
	NAM						■	■	■	■	■	■	■	■	■	■	■	■
	NAT[1]																	
Global	Application of pre-tactical ATFM planning						■	■	■	■	■	■	■	■	■	■	■	■
Regions	AFI[1]																	
	ASIA/PAC[1]																	
	CAR/SAM[1]																	
	EUR	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	MID[1]																	
	NAM						■	■	■	■	■	■	■	■	■	■	■	■
	NAT[1]																	
Global	Application of tactical ATFM planning						■	■	■	■	■	■	■	■	■	■	■	■
Regions	AFI[1]																	
	ASIA/PAC[1]																	
	CAR/SAM[1]																	
	EUR				■	■	■	■	■	■	■	■	■	■	■	■	■	■
	MID[1]																	
	NAM						■	■	■	■	■	■	■	■	■	■	■	■
	NAT[1]																	

1. To be developed.

REGIONAL AIR TRAFFIC MANAGEMENT SYSTEM IMPLEMENTATION OBJECTIVES BY STATE

REGIONAL AIR TRAFFIC MANAGEMENT SYSTEM IMPLEMENTATION BY STATE

Area of routing	Regions/States	ATM objective	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	. . . Region	Objective (e.g. reduced vertical separation minimum)																	
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
ARx	State . . .																		
	State . . .		TO BE DEVELOPED																
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
	. . . Region	Objective (e.g. reduced lateral separation minimum)																	
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
ARx	State . . .		TO BE DEVELOPED																
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
	. . . Region	Objective (e.g. application of RNP)																	
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
ARx	State . . .																		
	State . . .		TO BE DEVELOPED																
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		

Chapter 6

COMMUNICATIONS

INTRODUCTION

6.1 The material contained in this chapter complements that contained in Chapter 5 of Part I and in the communications sections of the FASIDs of the regional ANPs. This chapter is kept under review by the PIRGs and should be periodically updated to reflect the information contained in the communications sections of the regional FASIDs.

6.2 Considering the communications elements of the CNS/ATM systems infrastructure that support air traffic management, it is necessary to consider the ATM objectives for a given homogeneous ATM area and/or major international traffic flow as identified in Chapter 3 of Part I, followed by an assessment of the technical elements and implementation options that would most appropriately and cost-effectively meet the ATM objectives for that area and/or traffic flow.

SYSTEMS IMPLEMENTATION

6.3 Each regional planning group will develop its own work structure for accomplishing the work associated with the step-by-step approach identified in Chapter 3 of Part I. In some cases, an already established working group or CNS/ATM Subgroup may be in a suitable position to accomplish the work; in other cases, specific task forces or subgroups will need to be established.

6.4 To complete the tables in this chapter, the following steps from the global planning methodology outlined in Chapter 3 of Part I will need to be considered:

Step 6. Establish CNS and other technical and automation requirements necessary to support the desired ATM objectives identified in Step 5 (*operational analysis*).

Step 7. Analyse the benefits/improvements resulting from Steps 5 and 6 in order to establish (*operational analysis*):

a) costs-benefits;

b) relative priority;

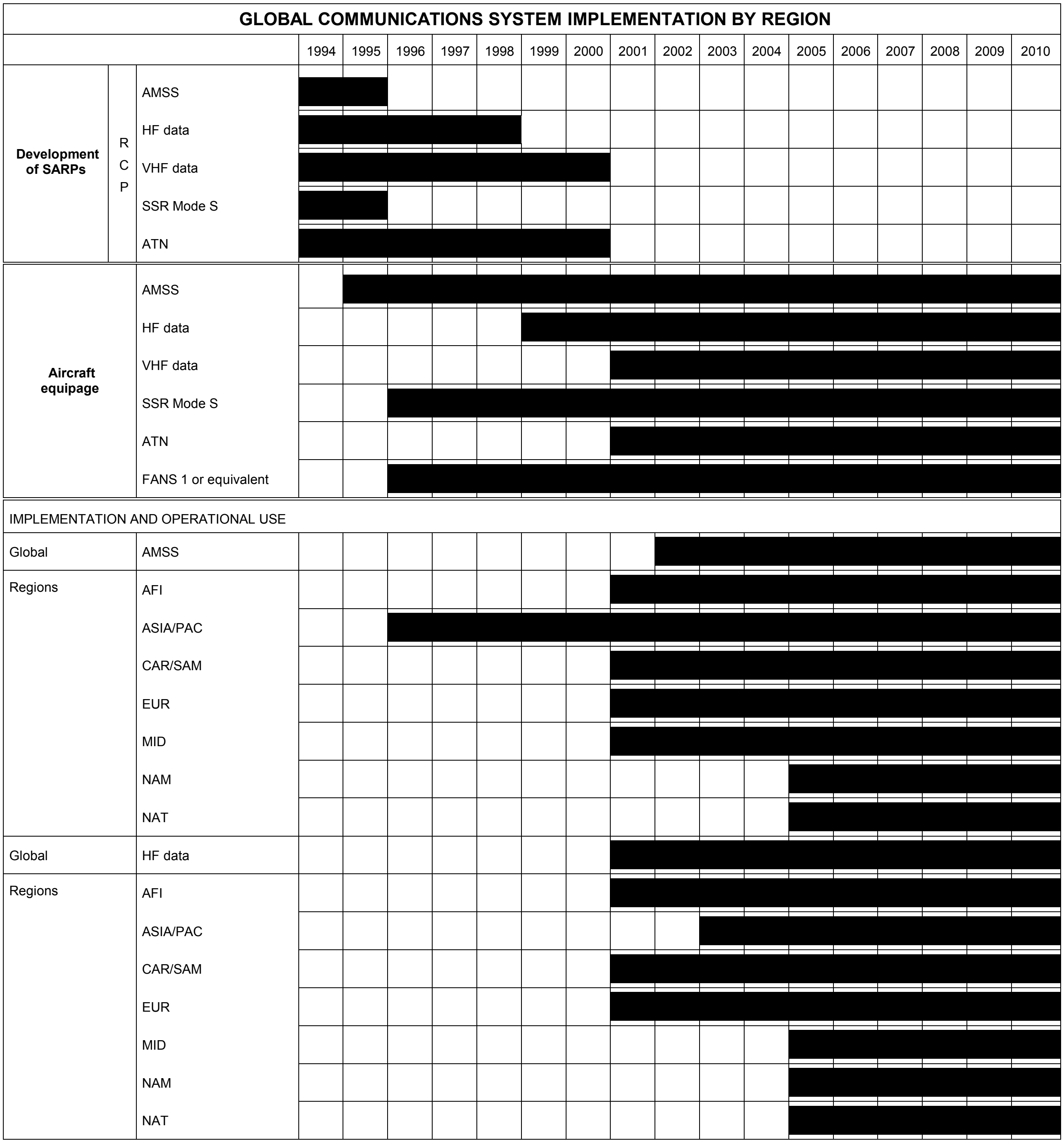
c) expected performance improvements; and

d) implementation dates of the various ATM objectives and CNS facilities for each of the homogeneous ATM areas and/or major traffic flows/routing areas (Chapters 5, 6, 7 and 8 of Part I, and Figures I-3-2 to I-3-5 of Chapter 3 of Part I refer).

Step 8. Considering the many technical solutions and implementation options available, repeat as necessary Steps 5, 6 and 7 to determine the most appropriate solution (*operational analysis*).

Proceed to Steps 9 through 12.

GLOBAL COMMUNICATIONS
SYSTEM IMPLEMENTATION OBJECTIVES BY REGION



GLOBAL COMMUNICATIONS SYSTEM IMPLEMENTATION BY REGION

		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Global	VHF data							■	■	■	■	■	■	■	■	■	■	■
Regions	AFI								■	■	■	■	■	■	■	■	■	■
	ASIA/PAC									■	■	■	■	■	■	■	■	■
	CAR/SAM									■	■	■	■	■	■	■	■	■
	EUR									■	■	■	■	■	■	■	■	■
	MID									■	■	■	■	■	■	■	■	■
	NAM											■	■	■	■	■	■	■
	NAT							■	■	■	■	■	■	■	■	■	■	■
Global	SSR Mode S				■	■	■	■	■	■	■	■	■	■	■	■	■	■
Regions	AFI							■	■	■	■	■	■	■	■	■	■	■
	ASIA/PAC					■	■	■	■	■	■	■	■	■	■	■	■	■
	CAR/SAM[1]																	
	EUR											■	■	■	■	■	■	■
	MID											■	■	■	■	■	■	■
	NAM										■	■	■	■	■	■	■	■
	NAT[1]																	
Global	ATN								■	■	■	■	■	■	■	■	■	■
Regions	AFI[1]																	
	ASIA/PAC									■	■	■	■	■	■	■	■	■
	CAR/SAM											■	■	■	■	■	■	■
	EUR								■	■	■	■	■	■	■	■	■	■
	MID													■	■	■	■	■
	NAM									■	■	■	■	■	■	■	■	■
	NAT[1]																	

1. To be developed

REGIONAL COMMUNICATIONS
SYSTEM IMPLEMENTATION OBJECTIVES BY STATE

REGIONAL AIR TRAFFIC MANAGEMENT SYSTEM IMPLEMENTATION BY STATE — COMMUNICATIONS COMPONENTS

Area of routing	Regions/States affected	System components	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	. . . Region	Component (e.g. ATN)																	
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
ARx	State . . .																		
	State . . .		TO BE DEVELOPED																
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
	. . . Region	Component (e.g. VHF data)																	
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
ARx	State . . .		TO BE DEVELOPED																
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
	. . . Region	Component (e.g. AMSS)																	
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
ARx	State . . .																		
	State . . .		TO BE DEVELOPED																
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		

Chapter 7

NAVIGATION

INTRODUCTION

7.1 The material contained in this chapter complements that contained in Chapter 6 of Part I and in the navigation sections of the FASIDs of the regional ANPs. This chapter is kept under review by the PIRGs and should be periodically updated to reflect the information contained in the navigation sections of the regional FASIDs.

7.2 Considering the navigation elements of the CNS/ATM systems infrastructure that support air traffic management, it is necessary to consider the ATM objectives for a given homogeneous ATM area and/or major international traffic flow as identified in Chapter 3 of Part I, followed by an assessment of the technical elements and implementation options that would most appropriately and cost-effectively meet the ATM objectives for that area and/or traffic flow.

SYSTEMS IMPLEMENTATION

7.3 Each regional planning group will develop its own work structure for accomplishing the work associated with the step-by-step approach identified in Chapter 3 of Part I. In some cases, an already established working group or CNS/ATM Subgroup may be in a suitable position to accomplish the work; in other cases, specific task forces or subgroups will need to be established.

7.4 To complete the tables in this chapter, the following steps from the global planning methodology outlined in Chapter 3 of Part I will need to be considered:

Step 6. Establish CNS and other technical and automation requirements necessary to support the desired ATM objectives identified in Step 5 (*operational analysis*).

Step 7. Analyse the benefits/improvements resulting from Steps 5 and 6 in order to establish (*operational analysis*):

a) costs-benefits;

b) relative priority;

c) expected performance improvements; and

d) implementation dates of the various ATM objectives and CNS facilities for each of the homogeneous ATM areas and major traffic flows/routing areas (Chapters 5, 6, 7 and 8 of Part I; and Figures I-3-2 to I-3-5 of Chapter 3 of Part I refer).

Step 8. Considering the many technical solutions and implementation options available, repeat as necessary Steps 5, 6 and 7 to determine the most appropriate solution (*operational analysis*).

Proceed to Steps 9 through 12.

GLOBAL NAVIGATION
SYSTEM IMPLEMENTATION OBJECTIVES BY REGION

1. To be developed
2. GPS has been approved as a long-range navigation aid to meet MNPS requirements.
3. Emerging concept or technology — consensus still to be reached.

GLOBAL NAVIGATION SYSTEM IMPLEMENTATION BY REGION

		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Global	Precision approach										■	■	■	■	■	■	■	■
Regions	AFI[1]																	
	ASIA/PAC											■	■	■	■	■	■	■
	CAR/SAM[1]																	
	EUR[1]																	
	MID[1]																	
	NAM[1]																	
	NAT[1]																	

1. To be developed

REGIONAL NAVIGATION SYSTEM IMPLEMENTATION OBJECTIVES BY STATE

REGIONAL AIR TRAFFIC MANAGEMENT SYSTEM IMPLEMENTATION BY STATE — NAVIGATION COMPONENTS

Area of routing	Regions/States	System	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	. . . Region	Component (e.g. GNSS)																	
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
ARx	State . . .																		
	State . . .		TO BE DEVELOPED																
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
	. . . Region	Component (e.g. WGS-84)																	
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
ARx	State . . .		TO BE DEVELOPED																
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
	. . . Region	Component (e.g. Precision approach)																	
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
ARx	State . . .																		
	State . . .		TO BE DEVELOPED																
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		

Chapter 8

SURVEILLANCE

INTRODUCTION

8.1 The material contained in this chapter complements that contained in Chapter 7 of Part I and in the surveillance sections of the FASIDs of the regional ANPs. This chapter is kept under review by the PIRGs and should be periodically updated to reflect the information contained in the surveillance sections of the regional FASIDs.

8.2 Considering the surveillance elements of the CNS/ATM systems infrastructure that support air traffic management, it is necessary to consider the ATM objectives for a given homogeneous ATM area and/or major international traffic flow as identified in Chapter 3 of Part I, followed by an assessment of the technical elements and implementation options that would most appropriately and cost-effectively meet the ATM objectives for that area or traffic flow.

SYSTEMS IMPLEMENTATION

8.3 Each regional planning group will develop its own work structure for accomplishing the work associated with the step-by-step approach identified in Chapter 3 of Part I. In some cases, an already established working group or CNS/ATM Subgroup may be in a suitable position to accomplish the work; in other cases, specific task forces or subgroups will need to be established.

8.4 To complete the tables in this chapter, the following steps from the global planning methodology outlined in Chapter 3 of Part I will need to be considered:

Step 6. Establish CNS and other technical and automation requirements necessary to support the desired ATM objectives identified in Step 5 (*operational analysis*).

Step 7. Analyse the benefits/improvements resulting from Steps 5 and 6 in order to establish (*operational analysis*):

a) costs-benefits;

b) relative priority;

c) expected performance improvements; and

d) implementation dates of the various ATM objectives and CNS facilities for each of the homogeneous ATM areas and major traffic flows/routing areas (Chapters 5, 6, 7 and 8 of Part I; and Figures I-3-2 to I-3-5 of Chapter 3 of Part I refer).

Step 8. Considering the many technical solutions and implementation options available, repeat as necessary Steps 5, 6 and 7 to determine the most appropriate solution (*operational analysis*).

Proceed to Steps 9 through 12.

GLOBAL SURVEILLANCE
SYSTEM IMPLEMENTATION OBJECTIVES BY REGION

GLOBAL SURVEILLANCE SYSTEM IMPLEMENTATION BY REGION

			1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Development of SARPs	RSP	ADS	■	■	■	■	■	■	■	■									
		ADS-B[1]			■	■	■	■	■	■									
		SSR Mode S	■	■															
Aircraft equipage		ADS									■	■	■	■	■	■	■	■	■
		ADS-B[1]									■	■	■	■	■	■	■	■	■
		SSR Mode S			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
IMPLEMENTATION AND OPERATIONAL USE																			
Global		ADS				■	■	■	■	■	■	■	■	■	■	■	■	■	■
Regions		AFI								■	■	■	■	■	■	■	■	■	■
		ASIA/PAC		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
		CAR/SAM												■	■	■	■	■	■
		EUR						■	■	■	■	■	■	■	■	■	■	■	■
		MID												■	■	■	■	■	■
		NAM						■	■	■	■	■	■	■	■	■	■	■	■
		NAT						■	■	■	■	■	■	■	■	■	■	■	■
Global		ADS-B[1]								■	■	■	■	■	■	■	■	■	■
Regions		AFI[2]																	
		ASIA/PAC[2]																	
		CAR/SAM[2]																	
		EUR[2]																	
		MID[2]																	
		NAM[2]																	
		NAT[2]																	
Global		SSR (Mode S)				■	■	■	■	■	■	■	■	■	■	■	■	■	■
Regions		AFI									■	■	■	■	■	■	■	■	■
		ASIA/PAC							■	■	■	■	■	■	■	■	■	■	■
		CAR/SAM[2]																	
		EUR									■	■	■	■	■	■	■	■	■
		MID													■	■	■	■	■
		NAM									■	■	■	■	■	■	■	■	■
		NAT[2]																	

1. Emerging concept or technology — consensus still to be reached.
2. To be developed.

REGIONAL SURVEILLANCE SYSTEM IMPLEMENTATION OBJECTIVES BY STATE

REGIONAL AIR TRAFFIC MANAGEMENT SYSTEM IMPLEMENTATION BY STATE — SURVEILLANCE COMPONENTS

Area of routing	Regions/States affected	System components	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	. . . Region	Component (e.g. ADS)																	
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
ARx	State . . .																		
	State . . .		TO BE DEVELOPED																
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
	. . . Region	Component (e.g. SSR Mode S)																	
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
ARx	State . . .		TO BE DEVELOPED																
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
	. . . Region	Component (ADS-B)																	
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
ARx	State . . .																		
	State . . .		TO BE DEVELOPED																
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		
	State . . .																		

— END —