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Global Air Navigation Plan

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International Civil Aviation Organization

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AMENDMENTS

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RECORD OF AMENDMENTS AND CORRIGENDA

AMENDMENTS		
No.	Date	Entered by

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No.	Date	Entered by

FOREWORD

The air transport industry plays a major role in world economic activity and remains one of the fastest growing sectors of the world economy. One of the keys to maintaining the vitality of civil aviation is to ensure that a safe, secure, efficient and environmentally sustainable air navigation system is available at the global, regional and national levels. This requires the implementation of an air traffic management system that allows optimum use to be made of enhanced capabilities provided by technical advances.

ICAO's efforts to address the needs of the air transport industry and international civil aviation as described above have aimed at coordinating the worldwide planning processes in support of a global air traffic management (ATM) system, as it evolves from the technology-based CNS/ATM systems concept. A plan of action was needed to advance implementation of CNS/ATM systems. The first such effort was the *Global Coordinated Plan for Transition to ICAO CNS/ATM Systems* (Global Coordinated Plan). A revised Global Coordinated Plan was published in 1998 as a "dynamic" document, comprising technical, operational, economic, environmental, financial, legal and institutional elements, and offering practical guidance and advice to regional planning groups and States on implementation and funding strategies. The revised document, which came to be known as the *Global Air Navigation Plan for CNS/ATM Systems* (Global Plan, Doc 9750) was developed as a strategic document to guide the implementation of CNS/ATM systems.

From that point, several States and all ICAO regions embarked on implementation programmes intended to improve aviation operations by making use of CNS/ATM technologies. However, it was later recognized that technology was not an end in itself and that a comprehensive concept of an integrated and global air navigation system, based on clearly established operational requirements, was needed. Such a concept, in turn, would form the basis for the coordinated implementation of CNS/ATM technologies based on clearly established requirements. To develop the concept, the ICAO Air Navigation Commission established the Air Traffic Management Operational Concept Panel (ATMCP).

The *Global Air Traffic Management Operational Concept* (Doc 9854) was subsequently endorsed by the Eleventh Air Navigation Conference in 2003. The operational concept is visionary in nature and intended to guide the high-level implementation of CNS/ATM technology by providing a description of how the emerging and future air navigation system should operate. This, in turn, will assist the aviation community in its transition from the air traffic control environment of the twentieth century to the performance-based, integrated and collaborative air traffic management system needed to meet aviation's needs in the twenty-first century.

This updated and revised version of the *Global Air Navigation Plan for CNS/ATM Systems*, re-titled as the *Global Air Navigation Plan*, was developed in consideration of the operational concept and the Strategic Objectives of ICAO. Most significantly, the revised Global Plan was developed on the basis of an industry roadmap which was developed in follow-up to the Eleventh Air Navigation Conference in an effort to facilitate implementation of the Recommendations of the Conference and ensure that focused efforts would lead to near- and medium-term benefits. The Global Plan, therefore, contains near- and medium-term guidance on air navigation system improvements necessary to support a uniform transition to the ATM system envisioned in the operational concept. Long-term initiatives will be added to the Global Plan as the technology matures and the supporting provisions are developed.

In accordance with the Global Plan, planning will be focused on specific performance objectives, supported by a set of "Global Plan Initiatives" ("initiatives"). These initiatives are options for air navigation system improvements that when implemented result in direct performance enhancements. States and regions will choose initiatives that meet performance objectives, identified through an analytical process, specific to the particular needs of a State, region, homogeneous ATM area or major traffic flow. A set of interactive planning tools will assist with the analytical process.

A planning framework has been developed to facilitate the planning processes in support of the Business Plan of the Organization. The framework will serve as an ICAO internal tool and will help to ensure the integration of the Global Plan and the regional plans and associated work programmes. The planning framework will be supported by software and a web site to serve as a mechanism for monitoring and review by management and governing bodies of the detailed activities and timelines which should lead to the realization of the global air navigation system as envisaged in the operational concept.

Several Global Plan-related documents and planning mechanisms form part of the overall planning framework. These are:

- The ATM System Requirements Document which is intended to support the Global ATM Operational Concept. The document is aimed at industry, and standards-making bodies and panels, and was developed to ensure that all ATM-related standards-making and industry work will be in support of the operational concept. It provides more detail than the concept, but less detail than would be found in an ICAO Standard or a system design document. An important characteristic of the requirements is that they reflect the holistic nature of the operational concept, emphasizing the air navigation system as a whole. Therefore, each requirement should be interpreted in the context of the other requirements and of the eleven expectations of the ATM community, detailed in Appendix D of Doc 9854.

- Guidance on performance-based transition planning, and establishing and measuring performance targets will be provided through a Performance Manual that is divided into two parts. Part One will consist of Performance–Based Transition Guidelines (PBTG). It provides guidance on how to adopt such a performance–based approach in the transition from today's system towards the future air navigation system as envisaged in the operational concept. Part Two offers specific guidance on setting and measuring performance targets. This Performance Manual will provide a comprehensive understanding of the intent, expected benefits and delivery mechanisms of the performance-based air navigation system envisioned in the operational concept and will support the planning process by facilitating the development of cost-effective global and regional work programmes.

In summary, the Global ATM Operational Concept provides the vision. The Global Air Navigation Plan, with its initiatives and associated interactive planning tools, serves as a strategic document providing the planning methodology that will lead to global harmonization. The performance framework will provide performance-based transition guidance, including guidance on how to choose performance objectives, set targets and measure the overall performance of the system, leading to the establishment of cost-effective global and regional work programmes in support of a global air navigation system. The table below depicts the structured planning framework described above.

ICAO documentation structure and relationships between work programmes in support of a global air navigation system

	DESCRIPTION	OBJECTIVE	ROLE	GUIDANCE
ATM Operational Concept (Doc 9854)	The ATM Operational Concept (ATMOC) presents the ICAO vision of an integrated, harmonized and globally interoperable air navigation system.The planning horizon is up to and beyond 2025.	To achieve an interoperable global air navigation system, for all users during all phases of flight, that meets agreed levels of safety, provides for optimum economic operations, is environmentally sustainable and meets national security requirements.	Vision	ATM System Requirements Document (to ensure that all ATM-related standards-making and industry work will be in support of the operational concept)
Global Air Navigation Plan (Doc 9750)	Strategic document that describes the methodology for global air navigation harmonization.	Establishes the focus for near- and medium-term activities.	Strategy	Performance Manual in two parts. Part I provides transition strategies and raises awareness of the way that evolution of ATM is planned at local, regional and global levels and supports the Global Plan as a transition planning document. Part II provides a comprehensive understanding of the intent, expected benefits and delivery mechanisms of the performance-based air navigation system envisioned in the operational concept and provides guidance on measuring and evaluating ATM performance
Global Plan Initiatives	A set of implementation methodologies derived from today's operational environment and available guidance materials.	Measurable progress towards the implementation of the ATMOC.	Tactics	
Regional Plans	Regional work programmes including the planning and monitoring of the detailed activities and their timelines which, inter alia, lead to the realization of a global air navigation system as envisaged in the operational concept.	Contains the performance directives and associated requirements for facilities and services, established through regional air navigation agreements, in support of the global air navigation infrastructure.	Action	ICAO Business Plan ICAO Strategic Objectives

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LIST OF ACRONYMS

A-SMGCS	Advanced surface movement guidance and control system
ACC	Area control centre
ADS	Automatic dependent surveillance
ADS-B	ADS-broadcast
ADS-C	ADS-contract
AEM	Advanced emission model
AFS	Aeronautical fixed service
ALLPIRG	All Chairmen of the Planning and Implementation Regional Groups
AMSS	Aeronautical mobile-satellite service
ANP	Regional air navigation plan
ANSEP	Air Navigation Services Economics Panel
ANSP	Air navigation services provider
AO	Aerodrome operations
AOM	Airspace organization management
APANPIRG	Asia/Pacific Air Navigation Planning and Implementation Regional Group
APIRG	Africa-Indian Ocean Planning and Implementation Regional Group
ASAS	Airborne separation assistance system
ASECNA	Agency for the Safety of Air Navigation in Africa and Madagascar
ATC	Air traffic control
ATFM	Air traffic flow management
ATM	Air traffic management
ATMCP	Air Traffic Management Operational Concept Panel
ATMOC	ATM operational concept
ATMSDM	ATM service delivery management
ATN	Aeronautical telecommunication network
ATS	Air traffic services
AUO	Airspace user operations
CAA	Civil aviation administration
CAEP	Committee on Aviation Environmental Protection
CASITAF	CNS/ATM Systems Implementation Task Force
CATCs	Civil aviation training centres
CM	Conflict management
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
CONUS	Continental United States
D-ATIS	Digital-automatic terminal information service
DCB	Demand and capacity balancing
DGCA	Director General of Civil Aviation
D-VOLMET	Digital meteorological information for aircraft in flight
EANPG	European Air Navigation Planning Group
ECAC	European Civil Aviation Conference
EUROCONTROL	European Organisation for the Safety of Air Navigation
FANS	Special Committee on Future Air Navigation Systems
FESG	Forecasting and Economic Analysis Support Group

FIR	Flight information region
FL	Flight level
FMS	Flight management system
FUA	Flexible use of airspace
GES	Ground earth stations
GHG	Greenhouse gas
GLONASS	Global orbiting navigation satellite system
GNSS	Global navigation satellite system
GPS	Global positioning system
GREPECAS	Caribbean/South American Regional Planning and Implementation Group
HF	High frequency
IATA	International Air Transport Association
IAVW	International airways volcano watch
ICAO	International Civil Aviation Organization
ICCAIA	International Coordinating Council of Aerospace Industries Associations
ILS	Instrument landing system
IMC	Instrument meteorological conditions
IPCC	Intergovernmental Panel on Climate Change
ITU	International Telecommunication Union
KPI	Key performance indicators
LTEP	Panel of Legal and Technical Experts on the Establishment of a Legal Framework with Regard to GNSS
MET	Meteorological services for air navigation
MIDANPIRG	Middle East Air Navigation Planning and Implementation Regional Group
MSAW	Minimum safe altitude warning
NAMPG	North American Planning Group
NAT SPG	North Atlantic Systems Planning Group
NLR	National Aerospace Laboratory
NM	Nautical miles
NOTAM	Notice to airmen
NPV	Net present value
OPMET	Operational meteorological information
PBTG	Performance-based transition guidelines
PIRGs	Planning and Implementation Regional Groups
PRM	Precision runway monitoring
RASP	Required ATM system performance
RNAV	Area navigation
RNP	Required navigation performance
RTSP	Required total systems performance
RVSM	Reduced vertical separation minimum
SADIS	Satellite distribution system for information relating to air navigation
SAGE	System of assessing aviation's global emissions
SARPs	Standards and Recommended Practices
SBAS	Satellite-based augmentation
SCAR	SADIS cost allocation and recovery scheme
SIDs	Standard instrument departures
SSR	Secondary surveillance radar
STARs	Standard instrument arrivals
SUA	Special use airspace
TMA	Terminal control area
TS	Traffic synchronization
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change

VDL	VHF digital link
VMC	Visual meteorological conditions
WATRS	West atlantic route system
WAFS	World area forecast system
WGS-84	World Geodetic System — 1984
WRC	World radiocommunication conferences

Chapter 1

EVOLUTION TO GLOBAL PLAN INITIATIVES

INTRODUCTION

1.1 This chapter of the Global Plan describes a strategy aimed at achieving near- and medium-term air traffic management (ATM) benefits on the basis of available and foreseen aircraft capabilities and ATM infrastructure. It contains guidance on ATM improvements necessary to support a uniform transition to the ATM system envisioned in the *Global Air Traffic Management Operational Concept* (Doc 9854). The operational concept presents the ICAO vision of an integrated, harmonized and globally interoperable ATM system. A global ATM system can be described as a worldwide system that, on a global basis, achieves interoperability and seamlessness across regions for all users during all phases of flight; meets agreed levels of safety; provides for optimum economic operations; is environmentally sustainable; and meets national security requirements.

1.2 There are many ways to present a transition map, and it would be difficult to address all aspects of ATM transition in one presentation. Therefore, the Global Plan focuses on one perspective, which is the operational and technical improvements that will bring near- and medium-term benefits to aircraft operators. Long-term initiatives, necessary to guide the evolution to a global ATM system as envisioned in the operational concept, will be added to the Global Plan as they are developed and agreed to.

1.3 On the basis of the above, planning will be focused on specific performance objectives, supported by a set of "Global Plan Initiatives" ("initiatives"). States and regions should choose initiatives that meet performance objectives, identified through an analytical process, specific to the particular needs of a State, region, homogeneous ATM area or major traffic flow. Planning tools will assist with the analytical process.

PLANNING PROCESS

Achieving a global ATM system

1.4 The basis for developing a global ATM system is 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. Appendix I contains the homogeneous ATM areas and major traffic flows/routing areas as identified by the Planning and Implementation Regional Groups (PIRGs). Further identification, update and analyses of these areas and traffic flows are carried out by PIRGs on an ongoing basis, in collaboration with the aircraft operators, reflecting the latter's requirements. For an up-to-date version of the major traffic flows or homogeneous ATM areas in any particular region, refer to relevant ICAO Regional Offices.

Homogeneous ATM area

1.5 A homogeneous ATM area is an airspace with a common ATM interest, based on similar characteristics of traffic density, complexity, air navigation system infrastructure requirements or other specified considerations. In such an ATM area a common detailed plan will foster the implementation of interoperable ATM systems. 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.

1.6 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, 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.

Major traffic flows/routing areas

1.7 A major traffic flow refers to a concentration of significant volumes of air traffic on the same or proximate flight trajectories. Major traffic flows may cross several homogeneous ATM areas with different characteristics.

1.8 A routing area encompasses one or more major traffic flows, defined for the purpose of developing a detailed plan for the implementation of ATM systems and procedures. A routing area may cross several homogeneous ATM areas with different characteristics. A routing area specifies common interests and requirements of underlying homogeneous areas, for which a detailed plan for the implementation of ATM systems and procedures either for airspace or aircraft will be specified.

1.9 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. The capabilities of the aircraft population are also important planning parameters that must be identified for the planning process. 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.

1.10 Homogeneous ATM areas and major traffic flows are related primarily to en-route airspace. However, addressing capacity and efficiency improvements in the terminal control area (TMA) and at aerodromes and working on the basis of a set of common initiatives, as described in this chapter, will serve as an important building block toward achieving a global ATM system. Therefore, several of the initiatives (Table 1-1 refers) were developed specifically to improve TMA and aerodrome operations.

Work programme

1.11 After identification of the homogeneous ATM areas and major traffic flows, in which all regions have already progressed substantially, planners should conduct a survey of the current and foreseen aircraft population and its capabilities, predicted traffic figures, and also the ATM infrastructure, including human resource availability and requirements, among other things. An analysis of the data gathered should lead to the identification of "gaps" in performance. The Global Plan initiatives would then be evaluated against these gaps to identify those that would most appropriately provide the operational improvements necessary to meet performance objective(s). This planning process would continue with the development of scenarios for implementation of initiatives, cost-benefit analyses of the various scenarios and preliminary development of infrastructure support requirements. Additional steps would include development of implementation plans and funding profiles, and further review of human resource requirements to support the identified initiatives, followed by further cost-benefit analyses. Finally, national and regional implementation plans would be developed or amended based on the selected initiatives. This is an iterative process which may require repetition of several steps until a final choice of initiatives is selected. The planning tools will assist planners in carrying out the above steps. Figure 1-1 is an illustration of a planning flow chart.

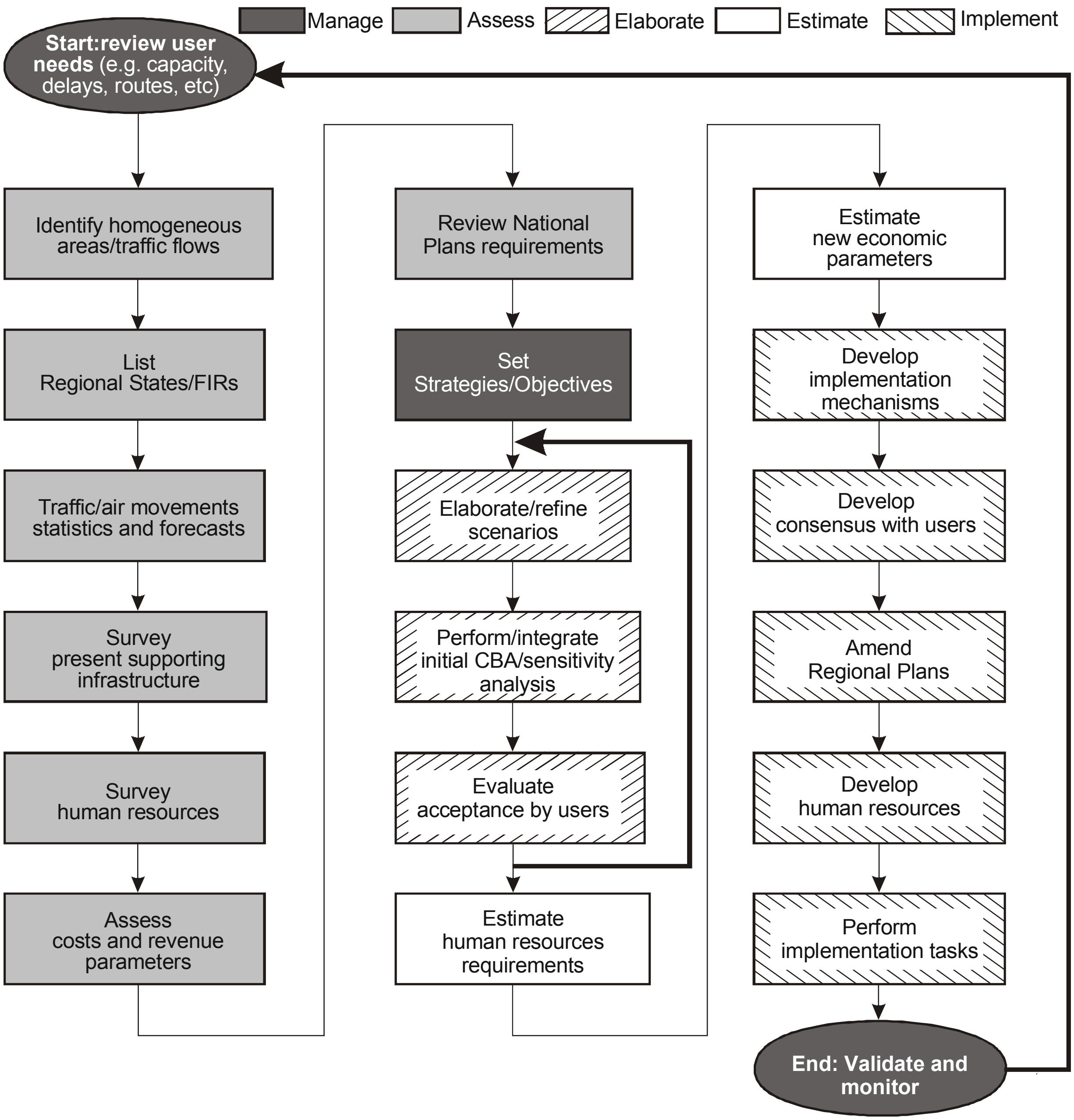

Figure 1-1. Planning flow chart

1.12 The planning process described in this volume of the Global Plan has been developed on the basis of the planning model contained in the previous version of the Global Plan which served as a step in the evolution toward a global ATM system. The updated process supports that evolution. Existing detailed plans are in different stages of implementation. Some plans have already identified performance objectives. The revised planning process, with its planning tools, will aid in furthering the work and provide the necessary guidance to complete the transition process.

1.13 The development of work programmes must be based on the experience and lessons learned in the previous cycle of the CNS/ATM implementation process. This Global Plan, therefore, focuses efforts toward maintaining consistent global harmonization and improving implementation efficiencies by drawing on the existing capabilities of the infrastructure and successful regional implementations over the near and medium terms. Therefore, PIRGs and States are encouraged to provide feedback on experience gained and lessons learned during the evolution toward implementation of a global ATM system. Regions are also well positioned to identify shortcomings in ICAO guidance material, planning processes or Standards. This iterative approach will help to ensure a successful planning process.

Planning tools

1.14 This Third Edition of the Global Plan is supported by planning tools which take various formats (e.g. software applications, planning documentation, web-based reporting forms, project management tools). As States and PIRGs consider implementation of the initiatives, they will use common programme templates contained in the planning tools as the basis to establish performance objectives and implementation timelines as well as to develop a comprehensive schedule and programme of planning activities to accomplish the work associated with the initiatives. In addition, the planning tools will provide links to relevant guidance material and documentation in order to assist the planner throughout the planning process. This will ensure a uniform approach to implementation of the initiatives. Appendix A describes the planning processes already in place and the relationships and interactions between the various planning bodies and documents.

EVOLUTION

Building an ATM system based on the operational concept

1.15 The sought-after global ATM system will be achieved through the implementation of many initiatives over several years on an evolutionary basis. The set of initiatives contained in this Global Plan are meant to facilitate and harmonize the work already underway within the regions and to bring needed benefits to aircraft operators over the near and medium term. ICAO will continue to develop newer initiatives on the basis of the operational concept which will be placed in this Global Plan. In all cases, initiatives must meet global objectives based on the operational concept. On this basis, planning and implementation activities begin with application of available procedures, processes and capabilities. The evolution would progress to application of emerging procedures, processes and capabilities and, ultimately, migrate to the ATM system based on the operational concept. Figure 1-2 depicts the Global Plan evolution.

Global Plan initiatives

1.16 Global Plan initiatives are designed to support the planning and implementation of performance objectives in the regions. Planning and implementation of performance objectives should be started in the near term and progress in an evolutionary manner. Long-term initiatives necessary to guide the evolution to a global ATM system will be added to the Global Plan as they are developed and agreed to. Only systems and projects that meet the criteria of Figure 1-1 should be implemented in a progressive, cooperative and cost-effective manner.

1.17 The ATM system will be based on the provision of integrated services. To better describe how these services will be delivered, seven concept components, together with their expected key conceptual changes, are described in the operational concept document (Doc 9854). Performance objectives should logically be linked to the operational concept components to ensure that all development work is aimed at achieving the ATM system envisaged in the concept. Therefore, the term: “related Operational Concept Components” when used in the initiative boxes numbered GPI-1 through GPI-23 refers to the seven concept components contained in the operational concept document. These are Airspace Organization and Management (AOM), Demand and Capacity Balancing (DCB), Aerodrome Operations (AO), Traffic Synchronization (TS), Conflict Management (CM), Airspace User Operations (AUO) and ATM Service Delivery Management (ATMSDM).

Integration of initiatives

1.18 The initiatives described in the following pages are provided to facilitate the planning process and should not be viewed as stand-alone work items, but rather, in many cases, as interrelated. Therefore, initiatives are quite capable of integrating with and supporting each other. In fact, integration is a sought-after goal of a global ATM system. An example would be the achievement of full integration of arrival, departure and surface traffic management which would improve aerodrome throughput through the sequencing and metering provided by the integration of arrival, departure and surface management functions. Benefits are achieved through the creation of an optimized traffic flow from the top of descent through the aerodrome to the top of climb. This could effectively eliminate ground and airborne holding, leading to more optimum use of the airspace, the runway system and ground facilities.

1.19 Achievement of the above would require implementation of several initiatives, or various parts of different initiatives, including decision support systems, performance-based navigation, collaborative airspace design and management, terminal area design and management, and aerodrome design and management.

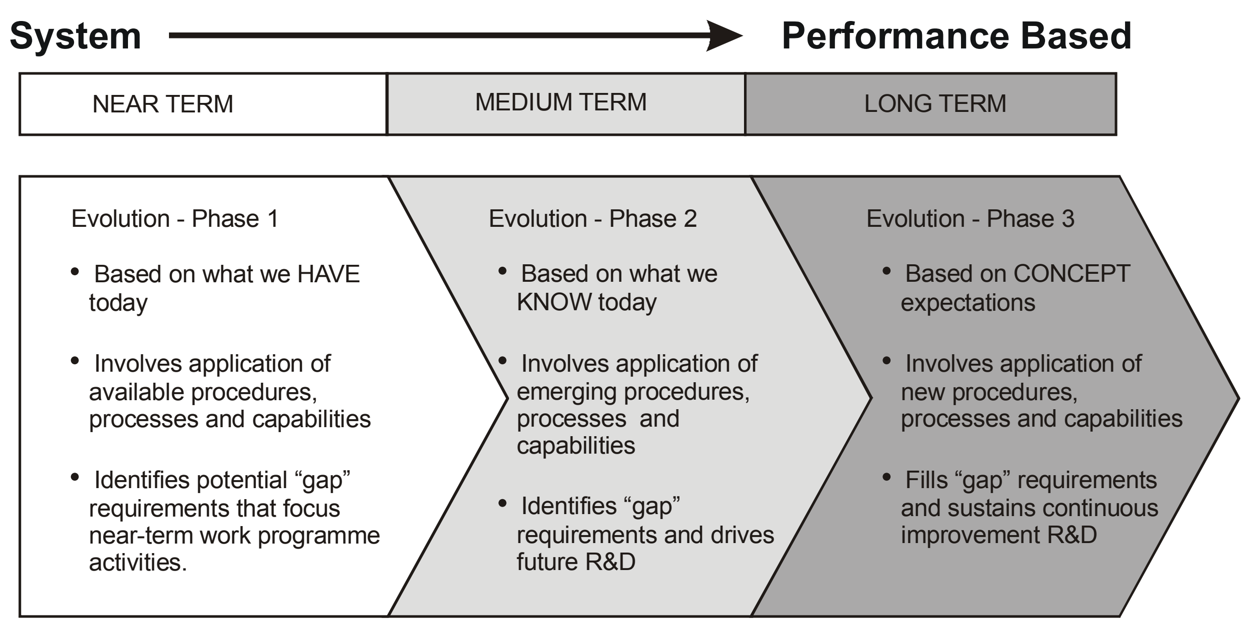

Figure 1-2. Global Plan evolution

Table 1-1. Global plan initiatives and their relationships to the major groupings

GPI		*En-route*	*Terminal Area*	*Aerodrome*	*Supporting Infrastructure*	*Related Operational Concept Components*
GPI-1	Flexible use of airspace	X	X			AOM, AUO
GPI-2	Reduced vertical separation minima	X				AOM, CM
GPI-3	Harmonization of level systems	X				AOM, CM, AUO
GPI-4	Alignment of upper airspace classifications	X				AOM, CM, AUO
GPI-5	RNAV and RNP (Performance-based navigation)	X	X	X		AOM, AO, TS, CM, AUO
GPI-6	Air traffic flow management	X	X	X		AOM, AO, DCB, TS, CM, AUO
GPI-7	Dynamic and flexible ATS route management	X	X			AOM, AUO
GPI-8	Collaborative airspace design and management	X	X			AOM, AUO
GPI-9	Situational awareness	X	X	X	X	AO, TS, CM, AUO
GPI-10	Terminal area design and management		X			AOM, AO, TS, CM, AUO
GPI-11	RNP and RNAV SIDs and STARs		X			AOM, AO, TS, CM, AUO
GPI-12	Functional integration of ground systems with airborne systems		X		X	AOM, AO, TS, CM, AUO
GPI-13	Aerodrome design and management			X		AO, CM, AUO
GPI-14	Runway operations			X		AO, TS, CM, AUO
GPI-15	Match IMC and VMC operating capacity		X	X	X	AO, CM, AUO
GPI-16	Decision support systems and alerting systems	X	X	X	X	DCB, TS, CM, AUO
GPI-17	Data link applications	X	X	X	X	DCB, AO, TS, CM, AUO, ATMSDM
GPI-18	Aeronautical information	X	X	X	X	AOM, DCB, AO, TS, CM, AUO, ATMSDM

GPI		*En-route*	*Terminal Area*	*Aerodrome*	*Supporting Infrastructure*	*Related Operational Concept Components*
GPI-19	Meteorological systems	X	X	X	X	AOM, DCB, AO, AUO
GPI-20	WGS-84	X	X	X	X	AO, CM, AUO
GPI-21	Navigation systems	X	X	X	X	AO, TS, CM, AUO
GPI-22	Communication infrastructure	X	X	X	X	AO, TS, CM, AUO
GPI-23	Aeronautical radio spectrum	X	X	X	X	AO, TS, CM, AUO, ATMSDM

(GPI-1) FLEXIBLE USE OF AIRSPACE

Scope: The optimization and equitable balance in the use of airspace between civil and military users, facilitated through both strategic coordination and dynamic interaction.

Related Operational Concept Components: AOM, AUO

Description of strategy

1.20 The use of airspace could be optimized through the dynamic interaction of civil and military air traffic services including real-time civil/military controller-to-controller coordination. This requires system support, operational procedures and adequate information on civilian traffic position and intentions.

1.21 The concept of flexible use of airspace (FUA) is based on the principle that airspace should not be designated purely as civil or military, but rather as a continuum in which all user requirements are accommodated to the greatest possible extent. FUA should result in the removal of large tracts of permanent or transient restricted airspace or special use airspace.

1.22 Where there are continued requirements to accommodate specific individual airspace uses, thereby blocking airspace of certain dimensions, this should be accommodated on a transient basis. Airspace should be released immediately after the operation requiring the restriction has been completed.

1.23 As reserved airspace is often established along critical flight paths at national boundaries, greater benefits associated with implementation of FUA will be obtained through inter-State cooperation which may entail regional and sub-regional agreements.

(GPI-2) REDUCED VERTICAL SEPARATION MINIMUM

Scope: The optimization of the utilization of airspace and enhanced aircraft altimetry systems.

Related Operational Concept Components: AOM, CM

Description of strategy

1.24 Reduced vertical separation minima (RVSM) reduces vertical separation to 300 m (1 000 ft) above FL 290 from the current 600 m (2 000 ft), thereby providing six additional flight levels. The *Manual on Implementation of a 300 m (1 000 ft) Vertical Separation Minimum Between FL 290 and FL 410 Inclusive* (Doc 9574) provides specific guidance on implementation of RVSM.

1.25 A great deal of experience has been gained with RVSM, and all necessary Standards and Recommended Practices (SARPs) guidance material are available to support implementation.

(GPI-3) HARMONIZATION OF LEVEL SYSTEMS

Scope: The adoption by all States of the ICAO Flight Level Scheme based on feet as contained in Appendix 3 to Annex 2 — *Rules of the Air.*

Related Operational Concept Components: AOM, CM, AUO

Description of strategy

1.26 The majority of ICAO Contracting States have chosen to use the imperial measurement system for referencing altitudes and levels; however, some States continue to use the metric system. To compound matters, some States that use the metric system have adopted different vertical spacing standards than what is contained in ICAO Annex 2 — *Rules of the Air*.

1.27 Aircraft registered in States that have adopted the imperial system have altimetry systems calibrated in feet. Those registered in States that have adopted the metric system generally have altimeters calibrated in metres. Aircraft operating across boundaries into States with differing systems are required to carry additional altimeters or to use conversion charts. Air traffic controllers handling such flights are also required to use conversion charts.

1.28 The implementation of RVSM at the interface between States using the different systems has increased safety concerns and caused the loss of several levels resulting in a less efficient operation for aircraft and a loss in airspace capacity. In addition, certain States that utilize the metric system have not made certain high-level cruising altitudes available, thereby imposing significant operating restrictions on aircraft operating on long-range sectors.

1.29 Harmonization of level systems, whereby all States adopt the ICAO Flight Level Scheme based on feet, should be pursued.

(GPI-4) ALIGNMENT OF UPPER AIRSPACE CLASSIFICATIONS

Scope: The harmonization of upper airspace and associated traffic handling through application of a common ICAO ATS Airspace Class above an agreed division level.

Related Operational Concept Components: AOM, CM, AUO

Description of strategy

1.30 To the extent possible airspace should be structured as a continuum, free from operational discontinuities, inconsistencies and differing rules and procedures. Alignment of airspace classifications can help to achieve this goal. It would also facilitate the introduction and better utilization of data link communications, improved flight plan processing systems, and advanced airspace management coordination tools and message exchange capabilities, leading to progressively more flexible and dynamic management of airspace. Airspace classifications should be harmonized intraregionally and, where possible, across several regions.

1.31 Air transport and most business aircraft operations should be contained within airspace within which positive air traffic control services are provided to all aircraft (i.e. Class A, B, C or D).

1.32 ATM provided in various airspace volumes should be based on the ICAO airspace classification system as defined in Annex 11 — *Air Traffic Services* (i.e. Class A to G), and those classifications should be implemented on the basis of a safety assessment, taking into account the volume and nature of the air traffic.

(GPI-5) RNAV AND RNP (PERFORMANCE-BASED NAVIGATION)

Scope: The incorporation of advanced aircraft navigation capabilities into the air navigation system infrastructure.

Related Operational Concept Components: AOM, AO, TS, CM, AUO

Description of strategy

1.33 The implementation of the concept of performance-based navigation will lead to increased capacity and enhanced efficiency through reductions in separation minima, bringing benefits to aircraft operators that equip to meet performance requirements. Performance-based navigation will also improve safety, particularly on approach, through a reduction of controlled flight into terrain.

1.34 A significant number of aircraft are capable of area navigation (RNAV) and required navigation performance (RNP). Where warranted, these capabilities should be further exploited to develop more efficient routes and aircraft trajectories that are not directly tied to ground-based navigation aids. Certain RNAV-equipped aircraft also have a significantly enhanced capability to achieve sequencing requirements to runways, particularly through the use of the "required time of arrival" function within the flight management system (FMS).

1.35 The performance-based navigation concept, which comprises RNAV and RNP operations, recognizes that a clear distinction must be made in the designation of operations, between those aircraft operations that require on-board self-contained performance monitoring and alerting and those that do not.

1.36 In accordance with the performance-based navigation concept, all phases of flight are addressed including en-route (oceanic/remote and continental), terminal and approach. The concept, its implementation processes, navigation applications, as well as the operational approval and aircraft qualification requirements, are described in the performance-based navigation manual which will be published as a new edition of the *Manual on Required Navigation Performance* (Doc 9613).

(GPI-6) AIR TRAFFIC FLOW MANAGEMENT

Scope: The implementation of strategic, tactical and pre-tactical measures aimed at organizing and handling traffic flows in such a way that the totality of the traffic handled at any given time or in any given airspace or aerodrome is compatible with the capacity of the ATM system.

Related Operational Concept Components: AOM, AO, DCB, TS, CM, AUO

Description of strategy

1.37 The implementation of demand/capacity measures, commonly known as air traffic flow management (ATFM), implemented on a regional basis where needed, will enhance airspace capacity and improve operating efficiency.

1.38 In the event that traffic demand regularly exceeds capacity, resulting in continuing and frequent traffic delays, or when it becomes apparent that forecast traffic demand will exceed the available capacity, the appropriate ATM units, in consultation with aircraft operators, should consider implementing steps aimed at improving the use of the existing system capacity and developing plans to increase capacity to meet the actual or forecast demand. Any such planning to increase capacity should be undertaken in a structured and collaborative manner.

1.39 Where warranted, States and regions should evolve to a collaborative-based approach to capacity management. The ATM Operational Concept envisages a more strategic approach to ATM overall, and through collaborative decision-making, a reduction in the reliance on tactical flow management. It is inevitable that tactical flow intervention will continue to be required; however closer coordination between airspace users and ATM service providers can reduce the need for routine tactical intervention which is often disruptive to aircraft operations.

(GPI-7) DYNAMIC AND FLEXIBLE ATS ROUTE MANAGEMENT

Scope: The establishment of more flexible and dynamic route systems, on the basis of navigation performance capability, aimed at accommodating preferred flight trajectories.

Related Operational Concept Components: AOM, AUO

Description of strategy

1.40 The implementation of ATS route structures that avoid concentrations of aircraft over congested points and implementation of an ATS routing environment that meets the needs of the airspace users to operate along preferred and dynamic flight trajectories, will increase capacity and increase aircraft operating efficiency.

1.41 RNAV routes are not restricted to the location of ground-based aids and provide benefits to aircraft operators and the ATM system. All modern aircraft are RNAV capable, and efforts should be made to design and implement RNAV routes.

1.42 Dynamic route management involves the aircraft in the planning process. Typical scenarios include the generation of change-of-routing requests by the dispatch functions of the aircraft operators, the processing and approval of these requests by ATS providers and transmission of the change-of-routing approval to the aircraft. Advanced scenarios would have the aircraft making requests directly to ATS providers who would process and modify the request if necessary and then forward the approved route to aircraft and affected service providers along the route of flight.

1.43 Random routing strategically or pre-tactically defines areas within which fixed routes are not designated and where aircraft determine an appropriate track from an entry point to an exit point.

1.44 User-preferred routes make use of the capability of aircraft operators to determine optimum tracks, based on a range of flight parameters. In accordance with this concept, ATS routes or tracks would not be fixed to pre-determined routes or waypoints, except where required for control purposes, however, trajectories would be available to ATM staff.

1.45 User-preferred routing requests are generated by the airspace user or their dispatch functions and submitted to the ATS provider for approval or renegotiation if a conflict results from their transmission to aircraft. Advanced scenarios would have the aircraft making requests directly to ATS providers who would process and modify the request if necessary and then forward the approved route to aircraft.

(GPI-8) COLLABORATIVE AIRSPACE DESIGN AND MANAGEMENT

Scope: The application of uniform airspace organization and management principles on a global basis, leading to a more flexible airspace design to accommodate traffic flows dynamically.

Related Operational Concept Components: AOM, AUO

Description of strategy

1.46 Collaborative airspace design and management is aimed at organizing airspace in a cooperative manner involving all users so that airspace is managed to accommodate the preferred trajectories of the users. States and regions should take advantage of aircraft capabilities when designing airspace. In designing and implementing airspace changes, account needs to be taken of the fleet capabilities among airspace users within a given airspace. Furthermore, collaboration with airspace users will identify procedures and/or solutions that make use of available aircraft capabilities.

1.47 Other emerging developments such as collaborative decision-making, the "required time of arrival" function in the flight management system (FMS), the endorsement of the global ATM operational concept and the implementation of data link applications, will also allow improved airspace design and management.

1.48 Over an evolutionary period, dynamic airspace management should be applied where significant benefits would be gained. Dynamic airspace management comprises integrated decision making; demand-based capacity (see air traffic flow management, 1.37); and user preferred routes (see dynamic and flexible ATS route management, 1.40).

1.49 Integrated decision making is an extension of the principles of the flexible use of airspace to include airspace users in flight in decision making with respect to tactical assessment of the use of reserved airspace and requirements for transit times of special use airspace.

1.50 Aircraft FMSs can provide information on estimated time en-route for proposed route changes. In addition, data link communication through controller-pilot data link communications (CPDLC), providing the ability to uplink and downlink flight planning information, can support deployment of integrated decision making.

(GPI-9) SITUATIONAL AWARENESS

Scope: Operational implementation of data link-based surveillance. The implementation of equipment to allow traffic information to be displayed in aircraft supporting implementation of conflict prediction and collaboration between flight crew and the ATM system. Improve situational awareness in the cockpit by making available electronic terrain and obstacle data of required quality.

Related Operational Concept Components: AO, TS, CM, AUO

Description of strategy

1.51 The further implementation of enhanced surveillance techniques (ADS-C or ADS-B) will allow reductions in separation minima and an enhancement of safety, increase in capacity, and improved flight efficiency, all on a cost-effective basis. These benefits may be achieved by bringing surveillance to areas where there is no primary or secondary radar, when cost-benefit models warrant it. In airspaces where radar is used, enhanced surveillance can bring further reductions in aircraft separation minima and improve, in high traffic density areas, the quality of surveillance information both on the ground and in the air, thereby increasing safety levels. The implementation of sets of quality-assured electronic terrain and obstacle data necessary to support the ground proximity warning systems with forward-looking terrain avoidance function as well as a minimum safe altitude warning (MSAW) system will benefit safety substantially.

1.52 Implementation of surveillance systems for surface movement at aerodromes where weather conditions and capacity warrant will also enhance safety and efficiency while implementation of cockpit display of traffic information and associated procedures will enable pilot participation in the ATM system and improve safety through greater situational awareness.

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

1.54 At terminal areas and at aerodromes surrounded by significant terrain and obstacles, the availability of quality-assured terrain and obstacle databases containing digital sets of data representing terrain surface in the form of continuous elevation values and digital sets of obstacle data of features, having vertical significance in relation to adjacent and surrounding features considered hazardous to air navigation, will improve situational awareness and contribute to the overall reduction of the number of controlled flight into terrain related accidents.

(GPI-10) TERMINAL AREA DESIGN AND MANAGEMENT

Scope: The optimization of the terminal control area (TMA) through improved design and management techniques.

Related Operational Concept Components: AOM, AO, TS, CM, AUO

Description of strategy

1.55 There are many ways that a well designed and managed TMA can have an important impact on safety, capacity and efficiency. TMA design should be implemented uniformly across all TMAs within a State or Region and should provide benefits while minimizing pilot/controller communications and optimizing pilot and controller workload. TMA arrival acceptance rates should be based tactically on a collaborative decision-making process involving tower, TMA and en-route sectors, while strategically involving airspace users, to ensure optimum traffic handling.

1.56 The enhancement of TMA management includes:

1) Complete implementation of WGS-84 (see WGS-84, 1.89);
2) Design and implementation of optimized RNAV and RNP arrival and departure procedures (see also RNAV and RNP (Performance-based navigation GPI-5);
3) Design and implementation of RNP-based approach procedures (see also Performance-based navigation in 1.34); and
4) Enhanced traffic and capacity management.

1.57 The implementation of dynamic TMA management procedures may comprise several elements such as dynamic wake vortex detection and mitigation, and collaborative capacity management.

1.58 At those locations where a business case supports implementation, decision support tools should be developed and implemented to provide a more structured and efficient management of arrival and departure traffic flows and more efficient use of the runway(s), more fuel-efficient trajectories and reduced noise exposure.

(GPI-11) RNP AND RNAV STANDARD INSTRUMENT DEPARTURES (SIDS) AND STANDARD TERMINAL ARRIVALS (STARS)

Scope: The optimization of the terminal control area (TMA) through implementation of improved ATS route structures based on RNP and RNAV, connecting the en-route phase of flight with the final approach, based on improved coordination processes.

Related Operational Concept Components: AOM, AO, TS, CM, AUO

Description of strategy

1.59 The implementation of optimized standard instrument departures (SIDs), standard instrument arrivals (STARs), instrument flight procedures, and holding, approach and associated procedures, taking advantage of aircraft navigation capabilities such as RNP and RNAV, as well as ATM decision support systems, will improve capacity and efficiency substantially.

1.60 The use of SIDs and STARs will maximize system capacity and predictability while easing the environmental impact, reducing fuel consumption, and reducing ATS coordination. States should take advantage of the performance characteristics that are currently available to design such route structures. Near-term benefits can be achieved by applying RNP1 and RNAV 2 and 1 criteria to the design of SIDs and STARs allowing optimum spacing between the routes leading to greater capacity and efficiency benefits (see 1.3.2).

1.61 SIDs and STARs allow the efficient transit of aircraft from the runway to en-route flight and vice versa, the segregation of departing traffic from arriving traffic to provide safe aircraft spacing, the maintaining of obstacle clearance requirements, the meeting of environmental requirements, and the provision of a predictable flight trajectory compatible with aircraft RNAV systems.

(GPI-12) FUNCTIONAL INTEGRATION OF GROUND SYSTEMS WITH AIRBORNE SYSTEMS

Scope: The optimization of the terminal control area (TMA) to provide for more fuel-efficient aircraft operations through FMS-based arrival procedures and functional integration of ground and airborne systems.

Related Operational Concept Components: AOM, AO, TS, CM, AUO

Description of strategy

1.62 In recent years there have been several efforts to develop flight procedures that provide the most efficient trajectory during an aircraft's approach to the destination aerodrome. These procedures allow an uninterrupted flight trajectory from top of descent until the aircraft is stabilized for landing. For the purposes of design work, it may be necessary to implement these procedures in phases.

1.63 The design of en-route and arrival air routes and associated procedures should facilitate the routine use of continuous descent procedures. Similarly, the design of departure procedures should facilitate the routine use of unrestricted climb procedures.

1.64 To maximize efficiency in TMA airspace, it is critical to take advantage of improved TMA design and make the best use of automation. Therefore, in addition to continuous descent capabilities, aircraft will increasingly be equipped with time-of-arrival computation. This capability will integrate with ground automation to deliver time of arrival over fixes to assist in the sequencing process allowing aircraft to remain closer to their 4-D preferred trajectory.

(GPI-13) AERODROME DESIGN AND MANAGEMENT

Scope: The implementation of management and design strategies to improve movement area utilization.

Related Operational Concept Components: AO, CM, AUO

Description of strategy

1.65 Improved aerodrome design and management activities, including coordination and collaboration between ATM providers, vehicle operators and aircraft operators can have an important impact on safety and capacity at aerodromes.

1.66 Local collaborative decision-making processes should lead to sharing of key flight scheduling data that would enable all participants (aerodrome, ATC, ATFM, aircraft operators and ground handling) to improve their awareness of aircraft status throughout the “turn around” process. This will allow minimal and precise ATFM measures to be applied and higher predictability of schedules to be achieved. Benefits would include more efficient use of aerodrome resources and ground handling, reduction in delays and greater predictability of schedules.

1.67 As an integral part of the air navigation system, the aerodrome will provide the needed ground infrastructure including, inter alia, lighting, taxiways, runway and runway exits, and precise surface guidance to improve safety and to maximize aerodrome capacity in all weather conditions. The ATM system should enable the efficient use of the capacity of the aerodrome airside infrastructure. To ensure optimum use of aerodromes:

a) runway occupancy time should be reduced where capacity and efficiency benefits would be gained;

b) the ability to safely manoeuvre in all weather conditions whilst maintaining capacity should be sought;

c) where warranted, precise surface guidance to and from a runway will improve capacity and efficiency; and

d) the position (to an appropriate level of accuracy) and intent of all vehicles and aircraft operating on the manoeuvring and movement areas should be known and available to the appropriate ATM community members at those aerodromes where a cost-benefit analysis shows that substantial capacity and efficiency gains would be achieved.

(GPI-14) RUNWAY OPERATIONS

Scope: Maximize runway capacity.

Related Operational Concept Components: AO, TS, CM, AUO

Description of strategy

1.68 Enhancing the performance of runway operations begins with the establishment of runway capacity benchmarks which are usually defined as the maximum number of flights an aerodrome can routinely handle in an hour for above Category I weather minimum. These benchmarks are estimates that vary with runway configurations and the mix of aircraft types. Where warranted, it should be an objective to utilize aircraft capabilities and available runways in the most appropriate manner to move the all weather throughput at as close to the levels of visual throughput as possible.

1.69 Achieving the optimum capacity for each runway is a complex task involving many factors, both tactical and strategic. In order to effectively manage that task it is essential to measure the effects of operational changes and to monitor performance of the airspace users and ATM providers. The latter case will be applicable to the analysis of pilot and controller performance and must recognize the requirement to maintain the confidence of the users and to work within the existing culture of safety. A system of performance indicators that forms the basis of measurements and analyses should be devised. Tactical factors affecting runway occupancy include flight operations and ATM factors. The flight operations aspects include operator performance, effects of company procedures, use of the airfield infrastructure, and aircraft performance issues.

1.70 Runway capacity constraints are defined by, inter alia, procedures, runway physical characteristics, aircraft performance capabilities, surveillance capabilities, aircraft spacing, weather limitations, environmental restrictions and surrounding land use management. Improved procedures for minimizing spacing such as reduced runway separation, precision runway monitoring (PRM) and RNP+-approaches for closely-spaced parallel runways will optimize spacing capability.

(GPI-15) MATCH IMC AND VMC OPERATING CAPACITY

Scope: Improve the ability of aircraft to manoeuvre on the aerodrome surface in adverse weather conditions.

Related Operational Concept Components: AO, CM, AUO

Description of strategy

1.71 It should be an objective of the ATM system to utilize all airborne and service provision capabilities to maintain visual meteorological conditions (VMC) capacity to the greatest practical extent during instrument meteorological conditions (IMC) . More use should be made of the capability of modern aircraft systems and ground systems in evolving toward this objective. Taxiway design and guidance capability may then be matched to those conditions.

1.72 Implementation of A-SMGCS, decision support tools and associated procedures offer the best solution for aircraft to operate in all weather conditions. At those locations where benefit/cost analysis indicates a positive value, the improved guidance and control of taxiing aircraft and moving vehicles on the movement area as well as impending conflict alert may be fully automated.

1.73 Synthetic vision, based on a detailed aerodrome map, can enhance situational awareness under adverse weather conditions where runway/taxiway markings may be obscured. Head-up display and guidance systems that can synthesize enhanced vision sensor data and synthetic vision images can offer an integrated solution to enhance situational awareness.

1.74 Enhanced conflict detection and alerting technologies and procedures will improve the aerodrome surface movement throughput while meeting established levels of safety. Controllers should also have access to systems to help them develop and maintain situational awareness of all traffic on the movement area in all weather conditions.

(GPI-16) DECISION SUPPORT AND ALERTING SYSTEMS

Scope: Implement decision support tools to assist air traffic controllers and pilots in detecting and resolving air traffic conflicts and in improving traffic flow.

Related Operational Concept Components: DCB, TS, CM, AUO

Description of strategy

1.75 Decision support systems facilitate early resolution of potential conflicts, provide basic levels of explorative probing to optimize strategies, and reduce the need for tactical action. The executive role of controllers is thereby enhanced, giving scope for management of more traffic within acceptable workload limits.

1.76 Several tools are available that have the ability to substantially enhance safety. These include minimum safe altitude warning systems, short-term conflict alert and runway incursion alerting tools. Tools that can improve efficiency include automated flight data processing systems, longer term conflict prediction and sequencing tools, and online data interchange systems.

1.77 Conflict prediction tools span several sectors and permit improved sectoral planning, thereby providing the advantage of more expeditious traffic flow and fewer potential conflicts within established arrival schedules. This will allow sector teams to operate more effectively and will result in more optimum and efficient arrival flows.

1.78 The automation of coordination tasks between adjacent sectors improves the quality of information on traffic transiting between sectors and makes it more predictable, thereby allowing reduced separation minima, decreased workload, increased capacity and more efficient flight operations.

(GPI-17) DATA LINK APPLICATIONS

Scope: Increase the use of data link applications.

Related Operational Concept Components: DCB, AO, TS, CM, AUO, ATMSDM

Description of strategy

1.79 The implementation of less complex data link services (e.g. pre-departure clearance, oceanic clearance, D-ATIS, automatic position reporting) can bring immediate efficiency benefits to the provision of ATS. Transition to the use of data link communications for more complex safety-related uses that take advantage of a wide variety of CPDLC messages, including ATC clearances, is already being successfully implemented.

1.80 Use of CPDLC and implementation of other data link applications can bring significant advantages over voice communication for both pilots and controllers in terms of workload and safety. In particular, they can provide efficient linkages between ground and airborne systems, improved handling and transfer of data, reduced channel congestion, reduced communication errors, interoperable communication media and reduced workload. The reduction of workload per flight translates into capacity increases and enhanced safety.

1.81 Communication data link and data link surveillance technologies and applications should be selected and harmonized for seamless and interoperable global operations. ADS-C, ADS-B and CPDLC are in service in various regions of the world but lack global harmonization. Current regional initiatives, including utilizing unique message subsets and CPDLC procedures, hinder efficient development and acceptance for global aircraft operations. Existing and emerging technologies should be implemented in a harmonized global manner in the near term to support long-term goals. Harmonization will define global equipage requirements and therefore minimize user investment.

1.82 FANS-1/A and aeronautical telecommunication network (ATN) applications support similar functionality, but with different avionics requirements. Many internationally-operated aircraft are equipped with FANS-1/A avionics initially to take advantage of data link services offered in certain oceanic and remote regions. FANS-1/A equipage on international business aviation aircraft is underway and is expected to increase.

(GPI-18) AERONAUTICAL INFORMATION

Scope: To make available in real-time quality assured electronic information (aeronautical, terrain and obstacle).

Related Operational Concept Components: AOM, DCB, AO, TS, CM, AUO, ATMSDM

Description of strategy

1.83 RNAV, RNP, computer-based navigation systems and ATM requirements introduced a need for new corresponding AIS requirements for quality and timeliness of information. To be able to cope and manage the provision of information and satisfy these new requirements, the traditional role of aeronautical information service should change into a system-wide information management service with changing duties and responsibilities.

Electronic information

1.84 To facilitate coordination, improve efficiency and safety and ensure that the ATM community shares the same information when collaborating on decisions, it is essential that quality assured electronic information (aeronautical, terrain and obstacle) be available in real-time. Electronic information will enhance pilots' situational awareness during en-route, terminal and aerodrome operations by loading on-board equipment with geo-referenced data sets containing en-route, terminal and aerodrome information. The same information may be made available at different ATC positions and pre-flight planning units as well as for access by airlines' flight planning departments or private/general aviation users. The electronic information can be tailored and formatted so that it satisfies ATM user requirements and applications. Standardized data formats will be used in creating the information databases which will then be populated with quality assured data sets.

(GPI-19) METEOROLOGICAL SYSTEMS

Objective: To improve the availability of meteorological information in support of a seamless global ATM system.

Related Operational Concept Components: AOM, DCB, AO, AUO

Description of strategy

1.85 Immediate access to real-time, global operational meteorological (OPMET) information is required to assist ATM in tactical decision-making for aircraft surveillance, air traffic flow management and flexible/dynamic aircraft routing which will contribute to the optimization of the use of airspace. Such stringent requirements will imply that most meteorological systems should be automated and that meteorological service for international air navigation be provided in an integrated and comprehensive manner through global systems such as the world area forecast system (WAFS), the international airways volcano watch (IAVW) and the ICAO tropical cyclone warning system.

1.86 Enhancements to WAFS, IAVW and the ICAO tropical cyclone warning system to improve the accuracy, timeliness and usefulness of the forecasts issued will be required to facilitate the optimization of the use of airspace.

1.87 Increasing use of data-link to downlink and uplink meteorological information (through such systems as D-ATIS and D-VOLMET) will assist in the automatic sequencing of aircraft on approach and will contribute to the maximization of capacity. The development of automated ground-based meteorological systems in support of operations in the terminal area will provide OPMET information (such as automated low-level wind shear alerts) and automated runway wake vortex reports. OPMET information from the automated systems will also assist in the timely provision of forecasts and warnings of hazardous weather phenomena. These forecasts and warnings, together with automated OPMET information, will contribute to maximizing runway capacity.

(GPI-20) WGS-84

Objective: The implementation of WGS-84 by all States.

Related Operational Concept Components: AO, CM, AUO

Description of strategy

1.88 The geographical coordinates used across various States in the world to determine the position of runways, obstacles, aerodromes, navigation aids and ATS routes are based on a wide variety of local geodetic reference systems. With the introduction of RNAV, the problem of having geographical coordinates referenced to local geodetic datums is more evident and has clearly shown the need for a universal geodetic reference system. ICAO, to address this issue, adopted in 1994 the World Geodetic System — 1984 (WGS-84) as a common horizontal geodetic reference system for air navigation with an applicability date of 1 January 1998.

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

(GPI-21) NAVIGATION SYSTEMS

Scope: Enable the introduction and evolution of performance-based navigation supported by a robust navigation infrastructure providing an accurate, reliable and seamless global positioning capability.

Related Operational Concept Components: AO, TS, CM, AUO

Description of strategy

1.90 Airspace users need a globally interoperable navigational infrastructure that delivers benefits in safety, efficiency and capacity. Aircraft navigation should be straightforward and conducted to the highest level of accuracy supported by the infrastructure.

1.91 To meet those needs, the progressive introduction of performance-based navigation must be supported by an appropriate navigation infrastructure consisting of an appropriate combination of global navigation satellite systems (GNSS), self-contained navigation systems (inertial navigation system) and conventional ground-based navigation aids.

1.92 GNSS provides standardized positioning information to the aircraft systems to support precise navigation globally. One global navigation system will help support a standardization of procedures and cockpit displays coupled with a minimum set of avionics, maintenance and training requirements. Thus, the ultimate goal is a transition to GNSS that would eliminate the requirement for ground-based aids, although the vulnerability of GNSS to interference may require the retention of some ground aids in specific areas.

1.93 GNSS-centered performance-based navigation enables a seamless, harmonized and cost-effective navigational service from departure to final approach that will provide benefits in safety, efficiency and capacity.

1.94 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 area navigation without any infrastructure investment, using the core satellite constellations and integrated multisensor airborne systems. The use of these systems already allows for increased reliability of non-precision approach operations at some airports.

1.95 Medium/longer-term applications will make use of existing and future satellite navigation systems with some type of augmentation or combination of augmentations required for operation in a particular phase of flight.

(GPI-22) COMMUNICATION INFRASTRUCTURE

Scope: To evolve the aeronautical mobile and fixed communication infrastructure, supporting both voice and data communications, accommodating new functions as well as providing the adequate capacity and quality of service to support ATM requirements.

Related Operational Concept Components: AO, TS, CM, AUO

Description of strategy

1.96 ATM depends extensively and increasingly on the availability of real-time or near real-time, relevant, accurate, accredited and quality-assured information to make informed decisions. The timely availability of appropriate aeronautical mobile and fixed communication capabilities (voice and data) to accommodate ATM requirements and to provide the adequate capacity and quality of service requirements is essential. The aeronautical communication network infrastructure should accommodate the growing need for information collection and exchange within a transparent network in which all stakeholders can participate.

1.97 The gradual introduction of performance-based SARPs and system-level and functional requirements will allow the increased use of commercially available voice and data telecommunication technologies and services. In the framework of this strategy, States should, to the maximum extent possible, take advantage of appropriate technologies, services and products offered by the telecommunication industry.

1.98 Considering the fundamental role of communications in enabling aviation, the common objective is to seek the most efficient communication network service providing the desired services with the required performance and interoperability required for aviation safety levels at minimum cost.

(GPI-23) AERONAUTICAL RADIO SPECTRUM

Scope: Timely and continuing availability of adequate radio spectrum, on a global basis, to provide viable air navigation services (communication, navigation and surveillance).

Related Operational Concept Components: AO, TS, CM, AUO, ATMSDM

Description of strategy

1.99 States need to address all regulatory aspects on aeronautical matters on the agendas for International Telecommunication Network (ITU) World Radiocommunication Conferences (WRC). Particular attention is drawn to the need to maintain the current spectrum allocations to aeronautical services.

1.100 The radio spectrum is a scarce natural resource with finite capacity for which demand from all users (aeronautical and non-aeronautical) is constantly increasing. Thus the ICAO strategy on aeronautical radio spectrum aims at long-term protection of adequate aeronautical spectrum for all radio communication, surveillance and radio navigation systems. The process of international coordination taking place in the ITU obliges all spectrum users (i.e. aeronautical and non aeronautical) to continually defend and justify spectrum requirements. Civil aviation operations are expanding globally creating pressure on the already stressed and limited available aeronautical spectrum.

1.101 The framework of this initiative involves the support and dissemination by States of the ICAO quantified and qualified policy statements of requirements for aeronautical radio frequency spectrum agendas for ITU World Radio-communication Conferences (WRC). This is necessary to maintain the current spectrum allocations to aeronautical services and ensure the continuing availability of adequate aeronautical radio spectrum and ultimately the viability of existing and new air navigation services globally.

Chapter 2

A PERFORMANCE-BASED SYSTEM THAT MEETS USER EXPECTATIONS

INTRODUCTION

2.1 The air navigation system is increasingly being discussed in terms of performance, as corporatization and a more structured regulatory environment place increasing pressure on accountability. This chapter of the Global Plan examines the need for adopting a performance orientation when designing, planning, implementing and operating ATM systems. This relates to Chapter One as each of the Global Plan Initiatives requires the identification of performance objectives to be established and monitored.

2.2 Performance may be seen from many perspectives. At the highest levels, performance relates to political and socio-economic expectations of society and/or the aviation community. The measures necessary to meet these expectations should govern the design of the system. These general expectations are relative to the effective operation of the ATM system and include *safety, security, environment, efficiency, cost-effectiveness, capacity, access and equity, flexibility, predictability, global interoperability and participation* by the entire aviation community.

2.3 The expectations often compete with each other. Some aviation community members (the *Global Air Traffic Management Operational Concept* (Doc 9854) refers) have explicit economic expectations, others favour efficiency and predictability, while some are concerned with access and equity; and all have safety expectations. For optimum air navigation system performance, each of these sometimes competing expectations needs to be balanced. In an integrated system, changes to one expectation area will likely have an effect on other areas. It is necessary, therefore, to assess the effect on the whole system when planning a change in a specific area. This may require, or lead to, trade-offs in performance. This is generally acceptable with the exception of safety, wherein acceptable levels of safety must be achieved.

2.4 Safety is the most critical of the expectations and in accordance with the ICAO requirements for States to implement safety management programmes, requiring air navigation service providers, aircraft operators and aerodrome operators to establish safety management systems, any significant safety-related change to the air navigation system, including the implementation of a reduced separation minimum or a new procedure, shall only be effected after a safety assessment has demonstrated that an acceptable level of safety will be met and users have been consulted. When appropriate, the responsible authority shall ensure that adequate provision is made for post-implementation monitoring to verify that the defined level of safety continues to be met.

2.5 The expectations for the global air navigation system have been discussed among the ATM community in general terms for many years. The eleven expectations listed in 2.2 have been agreed to and are included in the operational concept (Doc 9854) which was endorsed at the Eleventh Air Navigation Conference (Montreal, 22 September to 3 October 2003). The Thirty-Fifth Session of the ICAO Assembly (28 September to 8 October 2004), through Resolution A35-15, Appendix B, called upon States, as well as planning and implementation regional groups (PIRGs) and the aviation industry, to use the operational concept as the common framework to guide planning and implementation and to focus all such development work. The Assembly also urged the Council of ICAO to take the steps necessary to ensure that the future global air navigation system is performance-based and that the performance objectives and targets for the future system are developed in a timely manner.

Meeting user expectations

2.6 ICAO continues to develop key performance indicators (KPIs) for each of the eleven expectations as part of its work on the hierarchical performance model which includes the notion of required total system performance (RTSP) and required ATM system performance (RASP) (Agenda Item 3 of AN-Conf/11 Report (Doc 9828) refers). While these KPIs are being developed, and to further assist in describing the transition to a performance-based system, any change to the air navigation system should be driven by the four operational expectations of safety, capacity, efficiency and predictability, with cost effectiveness and environment as supporting expectations. These are the air navigation system dominant performance objectives and, within the performance framework identified in the operational concept, these would act at the RASP level.

Safety: any change to the air navigation system must not adversely affect acceptable levels of safety.

Capacity: any change to the air navigation system should be aimed at providing optimum capacity that meets current and forecast demand while minimizing delays. The system should be designed collaboratively, in particular through demand and capacity balancing, to limit system disruption.

Efficiency: any change to the air navigation system should be aimed at ensuring that user operating efficiency requirements are met.

Predictability: any change to the air navigation system should be designed to improve predictability and, therefore, user and service provider confidence.

Chapter 3

FACTORS AFFECTING CHANGE

INTRODUCTION

3.1 The implementation of the global plan initiatives requires addressing technical and operational aspects of operational improvements, as well as any factors that impact the effectiveness and the economic suitability of implementation. When considering the factors that affect change, it is fundamental to the evolution of the global ATM system to recognize that from a product perspective, the two key components are the aircraft and the ground-based ATM system. Based on this, there is a need for ATM providers to develop plans that aircraft operators can rely on, make decisions against, and have confidence that the operational improvements and associated benefits will be realized. Once a transition plan is agreed within the ATM community, there needs to be confidence that the plan will be followed to completion and that aircraft upgrades will be carried out.

Coordination

3.2 Early and effective coordination and cooperation of implementation planning activities between the members of the ATM community, particularly between ATM providers and aircraft operators, reduces proliferation of aircraft equipage requirements, facilitates cost-effectiveness in development of ATM infrastructure (e.g. communication, navigation and surveillance systems, ATC units), increases levels of interoperability and seamlessness, and enhances safety.

Transition

3.3 It is necessary to carefully transition to the ATM system defined in the operational concept in order to obtain the operational improvements expected from implementation of the global plan initiatives and to ensure interoperability and seamlessness. Initiatives should integrate into a continuous process of evolution of airborne and ground-based systems, taking into consideration backward and forward compatibility. Such an approach would allow continued evolution to the ATM system envisaged in the operational concept, while providing benefits in the near and medium terms.

Airborne systems

Lifespan

3.4 Aircraft manufacturers have to make business case decisions, in cooperation with their customers, about future ATM requirements in order to build adequate and cost-effective capabilities into an aircraft to meet those requirements. The production life cycle of an aircraft model can span many years. In addition, aircraft have a very low rate of retirement, especially business aircraft, which tend to have even longer life spans than commercial aircraft. These factors should be considered when planning changes to the ATM system and close collaboration between ATM providers, and aircraft and equipment manufacturers and operators, should be an integral part of the planning process.

Forward fit/retrofit

3.5 During the production life of an aircraft, changes to design are made to introduce improvements and functionality. These changes are introduced into the aircraft fleet primarily in two ways. During production they are introduced as forward fit. Concurrently, the aircraft manufacturer would produce a Service Bulletin (SB) describing changes that need to be made to allow previously delivered aircraft to be brought up to the latest functionality. This is known as retrofit which ensures fleet commonality. This is important from a training and Human Factors perspective as increasing complexity of the aircraft flight deck adds to flight crew training time, which adds cost and results in the crew being unavailable for flight operations. To avoid these added costs and requirements, it is important for the provider to first identify ATM solutions that do not require major changes to aircraft or their avionics. Additionally, changes should be planned to take place over long time spans to provide predictability and stability of aircraft operations. Where aircraft system changes are required, it is more efficient for aircraft operators if those changes are coordinated globally so that when changes are made to an aircraft, it covers all likely scenarios on a global basis.

Cost of unscheduled downtime

3.6 Operators schedule downtime very critically, and depending on the extent of the retrofit or change, other maintenance work may need to be deferred. It is essential therefore that, once agreed to, ATM initiatives requiring major upgrades to aircraft be followed through in accordance with agreed timelines.

Additional considerations

3.7 Equipage decisions are based on return on investment or, in the case of business aircraft, to preserve airspace access. Additionally, aircraft operators, manufacturers and equipment suppliers cannot afford to have a continuous rotation of equipment for modification. Therefore, structured update programmes are necessary.

Ground ATM systems

Impact of changes

3.8 Major changes to the ATM system can be lengthy processes requiring considerable investment in new infrastructure elements and extensive retraining of ATM staff and flight crew and redefinition of procedures. Furthermore, the impact of changes on aircraft operations varies, regardless of the size of the change from the ATM perspective. For example, replacement of an instrument landing system (ILS) with the same category ILS, or installation of a completely new area control centre (ACC), may have little or no effect on aircraft operations, even if a significant investment was made by the ATM provider. Conversely, an ATS route restructuring based on required navigation performance (RNP) and area navigation (RNAV), or the introduction of reduced vertical separation minimum (RVSM) which may require little investment on the part of the ATM provider, may require major aircraft or avionics upgrades. Similarly, elimination of ground navigation aids along with the introduction of global navigation satellite systems (GNSS) procedures may require aircraft modifications and training of flight crew.

3.9 It is essential therefore, that as well as providing sufficient notice of change, there is adequate coordination to ensure that the requirements for aircraft operation across several States and regions can be accommodated in a timely, efficient and cost-effective manner. This type of coordination also results in a positive return on investment for aircraft operators who equip early to meet the new ATM requirements. Additionally, ATM providers should consider implementing systems that are readily upgradeable over a long period and capable of integrating new and advanced capabilities that may have been at, or even beyond, the limits of predicted evolution at the time of the new systems design. An efficient approach to upgrading ATM capabilities would therefore be to specify open systems that allow integration of components from a variety of sources over a long period of time.

Long-term view

3.10 The development of some new components of the ATM system can be costly, requiring at least one major customer. The customer, however, needs the assurance that the system will be delivered on time and have long-term upgrade capabilities. The ATM provider may therefore wish to take a long-term view of the nature of the initiatives that will be introduced and limit their number, for which it is easy to quantify the cost benefits and for which there is a high degree of assurance of success with implementation.

Evolution

3.11 It is possible to produce a generic product to serve certain sections of the ATM system market, but at the level of major systems this is rarely the case. Evolution of new components should therefore take account of retrofit or re-use requirements which may impose additional cost pressures on the development of any given system. The development of harmonized initiatives and operational procedures across States and regions would lead to the successful and cost-effective implementation of a global ATM system.

Appendix A

Evolution of the planning process

Introduction

1.1 This Appendix of the Global Plan provides a historical synopsis of the evolution of CNS/ATM systems through to the planning for implementation of a global ATM system, also highlighting some of the benefits that could be expected from continued implementation efforts. It also provides general information for ATM planners on several aspects that must be considered when planning for implementation of a global ATM system. These include information on human resource development and training needs, legal issues, organizational and international cooperative aspects, cost-benefit and economic impacts, financial aspects, assistance requirements and technical cooperation, and environmental benefits associated with global ATM.

Background

The Special Committee on Future Air Navigation Systems (FANS)

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 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.

The communications, navigation, surveillance/air traffic management (CNS/ATM) system concept

1.8 In 1991, the Tenth Air Navigation Conference endorsed 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 communications, navigation, surveillance/air traffic management (CNS/ATM) systems, involved a complex and interrelated set of technologies, dependent largely on satellites. CNS/ATM was 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 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 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 succeeding sessions of the Assembly. These resolutions further endorsed and supported speedy implementation of CNS/ATM systems.

The global ATM operational concept

1.13 In order to further progress work on an ATM operational concept and focus the work on implementation of CNS/ATM systems, consensus had to be reached on several issues. In 1998, the Air Navigation Commission established the Air Traffic Management Operational Concept Panel (ATMCP) one purpose of which was to develop and describe an air traffic management operational concept that would facilitate the evolutionary implementation of a seamless, global ATM system. The concept was to be visionary in scope, not constrained by the present level of technology, and lead to realization of the benefits expected from CNS/ATM systems. The panel developed a draft *Global Air Traffic Management Operational Concept* (Doc 9854) in 2002, which was endorsed by the Eleventh Air Navigation Conference. Subsequently the operational concept was endorsed by the Thirty-fifth Session of the Assembly (28 September to 8 October 2004) in Resolution A35-15, which called upon States, Planning and Implementation

Regional Groups (PIRGs) and the aviation industry to use the ICAO global ATM operational concept as the common framework to guide planning and implementation of CNS/ATM systems and to focus all such development work on the global ATM operational concept.

GLOBAL PLANNING

Global ATM

1.14 The global ATM operational concept provides the basis from which the ATM operational requirements, objectives and benefits will be derived, thereby providing the foundation for the development of regional and national ATM implementation plans. ICAO is the only international organization in a position to effectively coordinate global ATM implementation activities leading to the realization of such a system. On this basis, a global ATM system can be described as a worldwide system that, on a global basis, achieves interoperability and seamlessness across regions for all users during all phases of flight; meets agreed levels of safety; provides for optimum economic operations; is environmentally sustainable; and meets national security requirements.

Global planning

1.15 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 Coordination 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 CNS/ATM systems had matured; therefore, a more concrete plan which would include all developments, while putting focus on regional implementation, was required.

1.16 In light of the above, the Council directed the ICAO Secretariat to revise the Global Coordinated 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 were addressed in the revised edition of the Global Coordinated Plan which was retitled as the *Global Air Navigation Plan for CNS/ATM Systems* (Doc 9750).

1.17 The Eleventh Air Navigation Conference (Montreal, 22 September to 3 October 2003) discussed the role and function of the Global Plan and agreed that the Global Plan was a significant component in the development of regional and national plans and that, together with the ATM operational concept, which was endorsed by the Conference, it provided an effective architecture for implementation of a global system based on the ATM operational concept.

1.18 In follow-up to the conference, the sixth meeting of the Air Navigation Commission Consultation with Industry, with the theme “Fostering the Implementation of the Recommendations of the Eleventh Air Navigation Conference”, was held in Montreal on 18 and 19 May 2004. Among the topics discussed was “Global ATM — From Concept to Reality”, which resulted in a conclusion encouraging industry partners to work together toward the development of common roadmaps/global action plans (roadmaps) for presentation to the Commission and consideration for inclusion in the Global Plan. In follow-up, two ATM Implementation Roadmaps were developed by dedicated project teams established by industry for this purpose. Subsequently, the Commission requested the Secretariat to develop a proposal for amendment of the Global Plan to incorporate relevant material from the roadmaps and to present the proposed amendment to the Commission for review.

1.19 This second amendment of the Global Plan was therefore developed on the basis of the recommendations of the Eleventh Air Navigation Conference and the logical groupings of operational initiatives taken from the roadmaps. The operational initiatives, as developed by industry, were consolidated in close cooperation with industry to allow a smooth integration with the well-established planning framework of the Planning and Implementation Regional Groups (PIRGs). The operational initiatives, renamed as Global Plan Initiatives (initiatives) contained in Chapter 1 of this Global Plan, are a logical progression of the evolutionary work already accomplished by the PIRGs and will integrate into the present planning framework, the goal being implementation of a global and harmonized ATM system. In fact, the "ATM objectives" contained in the Second Edition of the Global Plan, and which the PIRGs have been implementing to various degrees, are all embodied in the initiatives. Furthermore, the homogeneous ATM areas and major traffic flows/routing areas remain valid and are to be used as the basis for implementation. The primary objective of the industry is to ensure that maximum advantage is taken of presently available aircraft capabilities in the near and medium terms. Over the longer term, transition strategies being developed on the basis of the global ATM operational concept will eventually be incorporated into the Global Plan. Thus, the Global Plan will provide comprehensive guidance for transition to the global ATM system envisioned in the operational concept.

BENEFITS OF A GLOBAL ATM SYSTEM

1.20 A global ATM system will allow for an increase in airspace capacity, thereby improving efficiency, while at the same time not adversely affecting established safety levels. Furthermore, such a system will improve the handling and transfer of information, extend surveillance capabilities, and improve navigation. This will lead, among other things, to reductions in separation between aircraft and a subsequent increase in airspace capacity.

Benefits for the aircraft operators

1.21 Global ATM will also see the further implementation of automation systems to support increases in traffic. This will benefit the ATM community 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 flight operating costs and delays. Additionally, an important objective of global ATM is to permit aircraft operators to equip aircraft operating internationally with a minimum set of avionics usable everywhere.

1.22 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.

Benefits for States that provide the global air navigation infrastructure

1.23 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.

1.24 Global 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 underutilized 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

1.25 As the aviation industry grows, 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, by optimization of cruising levels and routes, and through implementation of continuous descent arrivals and approaches, it is expected that improvements in ATM could help reduce aviation fuel burn, thereby mitigating the effect of increased traffic on global aircraft engine emissions. Methodologies and tools for estimating global emissions and fuel usage for evaluating the impact of various global plan initiatives already exist. These are described in Appendix H.

Other benefits

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

- lower fares and rates;
- passenger time savings;
- transfer of high-technology skills;
- productivity improvements and industry restructuring;
- stimulation of related industries;
- enhanced trade opportunities; and
- increased employment.

ICAO'S PLANNING STRUCTURE FOR GLOBAL ATM

1.27 The vision of the international civil aviation community and that of ICAO is to achieve a seamless, global ATM system through the implementation of air navigation facilities and services in a progressive, cost-effective and cooperative manner. To facilitate the realization of this vision, ICAO has made significant progress in the development of material for the planning and implementation of air navigation systems at global, regional, subregional and national levels. Although implementation of systems in support of global ATM is well under way, the major challenge for ICAO is to guide the evolutionary development and transition to a 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. Figure A-1 illustrates the progression of the work of ICAO toward a global ATM system including the relationship between the various members of the ATM community.

The regional planning process

1.28 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. The development of regional plans for air navigation systems including CNS/ATM systems is undertaken by ICAO's PIRGs with the assistance of ICAO's Regional Offices, located in Bangkok, Cairo, Dakar, Lima, Mexico, Nairobi and Paris, and in coordination with ICAO Headquarters staff. The seven PIRGs are: Asia/Pacific Air Navigation Planning and Implementation Regional Group (APANPIRG), Africa-Indian Ocean Planning and Implementation Regional Group (APIRG), European Air Navigation Planning Group (EANPG), Caribbean/South American Planning and Implementation Regional Group (GREPECAS), Middle East Air Navigation Planning and Implementation Regional Group (MIDANPIRG), North American Planning Group (NAMPG) and North Atlantic Systems Planning Group (NATSPG). Figure A-2 details the planning process at the regional level.

1.29 In its most basic form, the output from the regional planning process is a listing of air navigation facilities and services, together with their achievable time frames, necessary for implementation. These listings are included in the Air Navigation Plans (ANPs), which are produced and maintained by PIRGs with the assistance of ICAO's Regional Offices.

1.30 Traffic forecasts have a special role in planning and implementation. 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 ATM. A uniform strategy has been adopted by ICAO for the purpose of preparing traffic forecasts in support of the regional planning process.

The national planning process

1.31 ICAO has been addressing the planning strategy 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 with regional requirements and implementation guidelines. It requires ongoing interaction with adjacent States, the regional planning group, and sub-regional groups to ensure harmonization and interoperability. This Global Plan will therefore assist States in developing their national plans. The national plan document, so structured, will direct the national work programme for a progressive, cooperative and cost-effective implementation. Figure A-3 explains the relationship between global, regional and national plans.

1.32 As the formulation of regional, subregional and national plans for CNS/ATM systems is progressively gaining maturity and States and aircraft operators are investing in the enabling technologies to gain early benefits, there is a need to address further steps to face the challenge of integration, interoperability and harmonization of the systems and procedures. To support this process, the current regional mechanism has been enlarged so as to include interregional coordination processes such as meetings of ICAO's Regional Directors and specifically focused meetings of neighbouring States of two or more regions. This type of coordination process results in implementation of systems and procedures through homogeneous ATM areas and major traffic flows covering several regions. This type of coordination will become more critical when planning for implementation of the global plan initiatives described in Chapter 1 of the Global Plan. ICAO will support and further develop the mechanisms and support structure to ensure interregional cooperation and coordination.

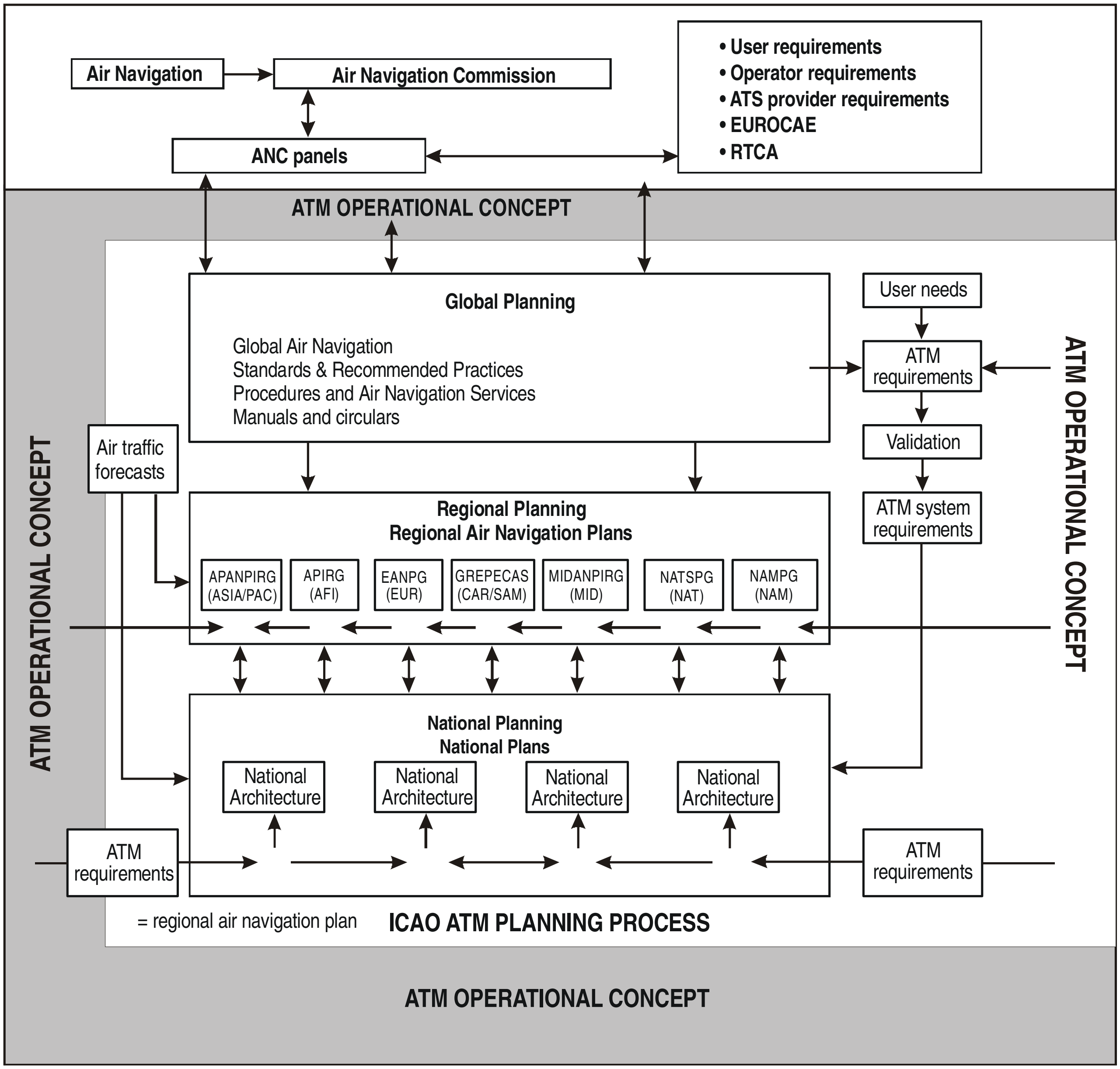

Figure A-1. Framework for achieving a global ATM system

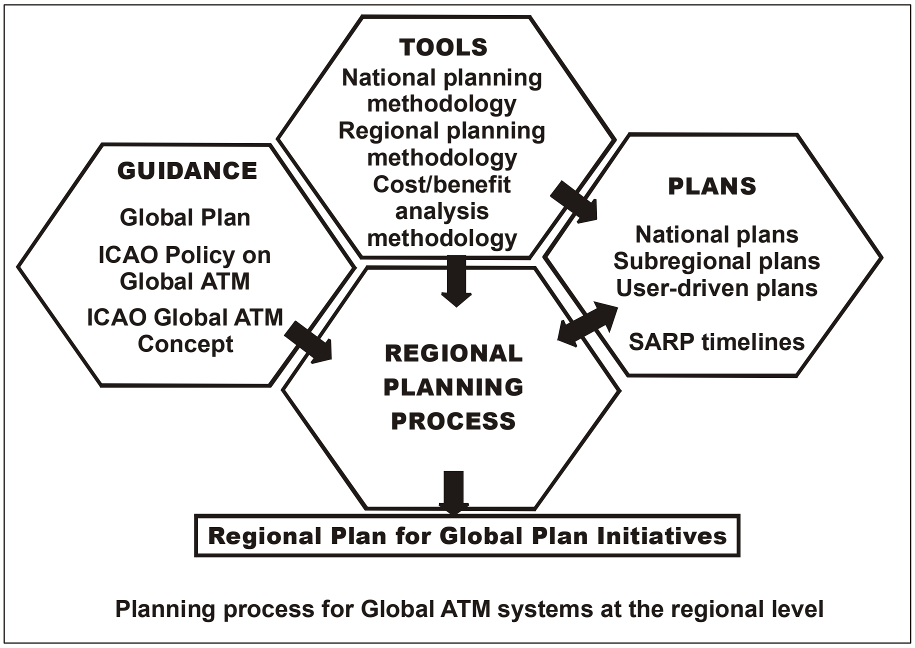

Figure A-2. Planning process at the regional level

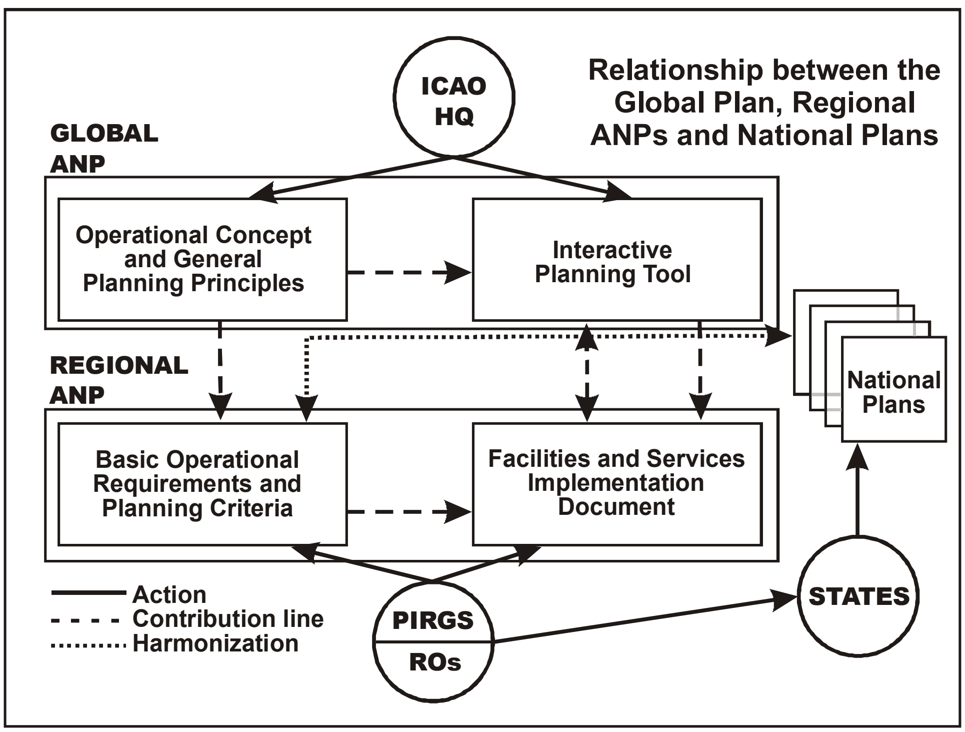

Figure A-3. Relationship between global, regional and national plans

Appendix B

HUMAN RESOURCE DEVELOPMENT AND TRAINING NEEDS

REFERENCES

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

INTRODUCTION

1.1 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 uniform quality level of training throughout the world.

1.2 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, CNS/ATM systems are based on many new concepts, and their implementation presents a greater challenge to trainers.

1.3 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 plan for implementation of CNS/ATM systems. This type of training is needed for managers who will plan the implementation of ATM systems, as well as those managers who will be responsible for planning the supporting CNS 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 is 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.

1.4 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

1.5 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) the Global ATM Operational Concept, including the supporting 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

1.6 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.

1.7 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) global ATM operational concept;

b) communications: AMSS, VDL, SSR Mode S data link, HF data link and ATN;

c) navigation: GNSS, including standard augmentation systems;

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

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

ATM OPERATIONAL IMPLEMENTATION PLANNING — TRAINING NEEDS

1.8 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;

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.

1.9 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

1.10 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. Third, the Organization does not directly participate in the operation of training institutions, but encourages and advises the Contracting States operating such facilities.

1.11 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.

1.12 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, 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 two 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; and

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.

HUMAN RESOURCE MANAGEMENT DEVELOPMENT DURING TRANSITION

1.13 Human resource management is an area of particular importance when considering transition to CNS/ATM systems. The main function of human resource management 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 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.

1.14 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.

1.15 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 planning for the future training resources needed to meet the demand for skilled human resources. The forecast provides an estimate of both the number of staff to be trained and the broad types of training required.

1.16 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.

1.17 Typically, human resource plans should project needs for at least three to 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. ICAO is developing a manual to assist States in human resource planning. The manual is designed to assist States in projecting human resource requirements for both new and existing technologies.

1.18 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.

1.19 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.

1.20 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 three to 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 loss or “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 an average wastage rate of three per cent per year may be used.

1.21 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.

1.22 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 of competency-based 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.

1.23 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 (web-based training) 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.

1.24 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.

Appendix C

LEGAL ISSUES

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

INTRODUCTION

1.1 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.

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

1.3 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.

1.4 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.

1.5 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", Attachment 1 to this appendix, refers). Consideration of other legal issues has led to 16 Recommendations (Attachment 2 to this appendix refers). The material in this appendix 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

1.6 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

1.7 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

1.8 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.

1.9 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 the Global Positioning System (GPS) and the Global Orbiting Navigation Satellite System (GLONASS), respectively.

1.10 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 augmentation 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.

1.11 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

1.12 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.

1.13 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.

1.14 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.

1.15 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

1.16 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.

1.17 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 global planning and implementation

1.18 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.

1.19 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

1.20 Paragraph 7 of the Charter provides that with a view to facilitating global planning and implementation 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.

1.21 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.

1.22 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.

1.23 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

1.24 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 (Attachment 2 to this appendix 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 (Attachment 3 to this appendix refers). The 33rd Session of the Assembly adopted Resolution A35-3 (Attachment 4 to this appendix refers).

Certification

1.25 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 Attachment 2 to this appendix).

Liability

1.26 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.

Administration, financing and cost-recovery

1.27 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.

Future operating structures for GNSS

1.28 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 and 16 put forward by LTEP address the related issues and identify certain possible fields of international action.

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Attachment 1 to Appendix C

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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Attachment 2 to Appendix C

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 3 bis*

The Panel recommends to the Council that:

a) 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;

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

c) 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.

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

Attachment 3 to Appendix C

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.

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Attachment 4 to Appendix C

A35-3: A PRACTICAL WAY FORWARD ON LEGAL AND INSTITUTIONAL ASPECTS OF COMMUNICATIONS, NAVIGATION, SURVEILLANCE/ AIR TRAFFIC MANAGEMENT (CNS/ATM) SYSTEMS

Whereas the global implementation of Communications, Navigation, Surveillance/Air Traffic Management (CNS/ATM) systems, which, *inter alia*, is intended to provide safety-critical services for aircraft navigation, has made substantial progress since its inception at the 10th Air Navigation Conference in 1991 and received enthusiastic endorsement at the 11th Air Navigation Conference in 2003;

Whereas the existing legal framework for CNS/ATM systems, namely the Chicago Convention, its Annexes, Assembly Resolutions (especially including the Charter of GNSS Rights and Obligations), associated ICAO guidance (especially including the Statement of ICAO Policy on CNS/ATM Systems Implementation and Operation), regional navigation plans, and exchanges of letters between ICAO and the States operating satellite navigation constellations has enabled the technical implementation achieved thus far;

Whereas ICAO has devoted substantial resources to the study of the legal and institutional aspects of CNS/ATM systems in the ICAO Assembly, the Council, the Legal Committee, and a Panel of Legal and Technical Experts and a Study Group, building a detailed record and developing an understanding of the issues, challenges, and concerns facing the global community; and

Whereas there is a need to also consider regional initiatives to develop measures addressing any legal or institutional issues that could inhibit the implementation of CNS/ATM in the region, while ensuring that such mechanisms will be consistent with the Chicago Convention;

The Assembly:

1. *Recognizes* the importance of Item No. 1 of the General Work Programme of the Legal Committee "Consideration, with regard to CNS/ATM systems including global navigation satellite systems (GNSS), of the establishment of a legal framework", and resolutions or decisions by the Assembly and the Council relating to it;

2. *Reaffirms* that there is no need to amend the Chicago Convention for the implementation of CNS/ATM systems;

3. *Invites* Contracting States to also consider using regional organizations to develop mechanisms necessary to address any legal or institutional issues that could inhibit the implementation of CNS/ATM in the region, while ensuring that such mechanisms will be consistent with the Chicago Convention, and public international law;

4. *Encourages* the facilitation of technical assistance in implementation of CNS/ATM systems by ICAO, regional organizations and industry;

5. *Invites* Contracting States, other multilateral agencies and private financiers to consider development of additional sources of funding for assistance to States and regional groups in implementation of CNS/ATM;

6. *Directs* the Secretary General to monitor and, where appropriate, assist in the development of contractual frameworks to which parties may accede, *inter alia*, on the basis of the structure and model proposed by the Members of the European Civil Aviation Conference and the other regional civil aviation commissions, and on international law;

7. *Invites* the Contracting States to transmit regional initiatives to the Council; and

8. *Directs* the Council to register such regional initiatives, to consider their value and to make them public as soon as possible (in accordance with Articles 54, 55 and 83 of the Chicago Convention).

Appendix D

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

1.1 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 bodies 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

1.2 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.

1.3 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.

1.4 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 9082/7, paragraph 15, refers) that States establish an independent mechanism for the economic regulation of the services. A State should, where necessary, stipulate as a condition for its approval of a new autonomous body or entity, that the entity observe all relevant obligations of the State 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

1.5 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 or practical for a State to implement such systems for its sole use.

1.6 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.

Communication satellite services implementation and option selection

1.7 The satellite-based system serving the needs of CNS/ATM systems communications 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.

1.8 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 Agence pour la Sécurité de la Navigation Aérienne en Afrique et à Madagascar (ASECNA), Corporación Centroamericana de Servicios de Navegación Aérea (COCESNA) and European Organisation for the Safety of Air Navigation (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.

1.9 Autonomous civil aviation organizations may prefer to establish direct technical and commercial relationships with satellite service providers where this is possible and feasible.

1.10 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)

1.11 The GNSS will initially be composed of satellite systems that provide standard positioning service and system augmentations, which may have wide area or local area coverage. System augmentation is required for meeting certain performance requirements. 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 (GPS). Both these systems are originally military systems, which are being made available for civilian use. Unless 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 provider States. The GALILEO core satellite constellation, being developed by the European Union Member States, is intended to be a civilian controlled and operated system designed to fulfill the requirements of a variety of users including civil aviation. Similar to GPS and GLONASS, GALILEO Open Service will provide a positioning service to aviation free of direct user charges.

1.12 System augmentation gives rise to somewhat different considerations. For example, a satellite-based augmentation system (SBAS) could be provided by the same State(s) or entity that operates a core 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 for communication satellite services 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 will be addressed later, 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 provider association, or an international aviation user association, for dealing with the service provider, may be the most appropriate.

1.13 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)

1.14 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.

1.15 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

General

1.16 International cooperative ventures in the provision of air navigation services have normally proven to be highly cost-effective for the provider States as well as the users, and in some instances have constituted the only means for implementing costly facilities and services which offer capacity that exceeds the requirements of individual States. By cooperating in such facility or service provision the States concerned have been able to provide more efficient services and at lower cost than if they had to finance the facilities concerned themselves. The ICAO's Policies on Charges (Doc 9082/7) encourages international cooperation in the provision and operation of air navigation services where this is beneficial for the providers and users concerned.

1.17 According to Assembly Resolution A35-14, Appendix X, States are expected to give consideration to cooperative efforts for introducing more efficient airspace management, in particular the upper airspace, taking into account the need for cost-effective introduction and operation of CNS/ATM systems. In this context Contracting States should consider, as necessary, establishing jointly a single Air Traffic Services Authority to be responsible for the provision of air traffic services within ATS airspace extending over the territories of two or more States or over the high seas. Also, operating agencies are referred to in ICAO Assembly Resolutions A22-19 "Assistance and advice in the implementation of Regional Plans" and A16-10 "Economic, financial and joint support aspects of implementation."

1.18 The international cooperation may take different forms. In its simplest form there is a coordination and harmonization process initiated as a sub-regional 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 air navigation facilities and services across borders with neighbouring States. Examples of such sub-regional activities are Roberts FIR Organization in Africa and Piarco FIR in Eastern Caribbean. An example of a regional activity is the initiative to cooperation in search and rescue (SAR) services in Africa. A more formal machinery for cooperation may be established as a Multinational Facility/Service, an International Operating Agency, a Joint Charges Collection Agency, or an ICAO Joint Financing Arrangement. With reference to Assembly Resolution A35-14, a political cooperation, known as the Single European Sky, has emerged within the framework of the European Union Treaty.

The multinational facility or service in the context of CNS/ATM systems implementation

1.19 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.

1.20 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

1.21 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.

1.22 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.

1.23 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. 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

1.24 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 requirements 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

1.25 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 3 of the *Manual on Air Navigation Services Economics Manual* (Doc 9161)). The ICAO Council 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.

A global approach to cost recovery of regional monitoring agencies

1.26 A practical application of the multinational facility/service concept is the approach developed by ICAO for cost recovery of the required regional monitoring agency (RMA) infrastructure for reduced vertical separation minima (RVSM). In directives to ICAO's regional offices and the regional planning and implementation groups (PIRGs) it is recommended that RMAs be implemented as "multinational (ICAO) air navigation facilities/services" as and when appropriate, using the following steps:

a) define, at a PIRG meeting, the RVSM monitoring function as a Multinational (ICAO) Air Navigation Facility/Service in accordance with the existing guidelines on the establishment and provision of multinational ICAO air navigation facilities/services, included in the regional air navigation plan concerned;

b) agree to a cost-sharing arrangement based on, for example, distance flown or number of flights within the airspace for which each of the respective States has assumed responsibility, it being understood that distance flown may offer more precision while allocation based on the number of flights is simpler to administer;

c) find and assign a State or an existing organization or agency to establish and operate the RMA (the PIRG's responsibility);

d) develop and establish an administrative agreement to regulate the establishment and operation of the RMA, including the cost-sharing arrangement and procedures for collection of contributions from the participating States (the PIRG, assisted by the ICAO regional office);

e) sign the administrative agreement (DGCAs or some other authorized person in the participating States);

f) establish and operate the RMA as a Multinational (ICAO) Air Navigation Facility/Service in accordance with the administrative agreement (the assigned operator); and

g) recover the contributions to the financing of the RMA through additions to the cost bases for route charges and transfer the amounts to the RMA operator (each State).

International operating agencies

1.27 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

1.28 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.

1.29 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 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 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.

1.30 The ICAO Council recommends that States or their delegated service providers consider participating in joint charges collection agencies whenever this is advantageous (*ICAO's Policies on Charges* in Doc 9082/7, paragraph 18).

Joint financing arrangements

1.31 Joint financing 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. 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 Chicago Convention where the basic principles for a joint support are laid down.

1.32 Under a joint financing 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.

1.33 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.

1.34 A related example of a joint financing 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.

Appendix E

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

1.1 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 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

1.2 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, the reduction in 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.

1.3 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.

1.4 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.

1.5 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 *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). 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.

INTERPRETATION OF COST-BENEFIT RESULTS

1.6 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.

1.7 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.

1.8 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.

1.9 The resulting effect on the airlines' net financial benefit attributable to implementation of CNS/ATM systems in a region or State must be examined.

1.10 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

1.11 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.

1.12 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

1.13 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.

1.14 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.

1.15 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 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

1.16 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 time savings, improve safety, produce environmental benefits and may also lead to some industry restructuring and changes in skills required.

1.17 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 time savings, they represent an additional benefit. The evaluation of this benefit is discussed in Circular 257.

1.18 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 will be necessary, with further economic and social consequences.

1.19 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.

1.20 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.

Summary of Economic Effects of CNS/ATM

— Financial benefits and lower fares and rates
— Improved safety
— Passenger time savings
— Environmental benefits
— Transfer of high-tech skills
— Productivity improvements and industry restructuring
— Higher traffic and stimulation of related industries

Appendix F

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

1.1 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

1.2 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 policies on charges for airports and air navigation services. This policy is contained in Article 15 of the Chicago Convention and is supplemented by *ICAO's Policies on Charges for Airports and Air Navigation Services* (Doc 9082/7). The implementation of CNS/ATM systems should not require any basic changes to that policy.

1.3 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 *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 among States in their cost-recovery efforts is strongly recommended."

1.4 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 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."

1.5 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."

1.6 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.

1.7 In ICAO's policies on charges, pre-funding of projects is considered as a possible source of financing and the following policy guidance is included 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

1.8 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.

1.9 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.

1.10 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

1.11 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, implementation of CNS/ATM systems offers the cost saving potential of merging many FIRs and correspondingly reducing the number of ATM facilities. Nevertheless, even without an en-route ATM 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 ATM 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.

1.12 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.

1.13 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

1.14 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

1.15 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

1.16 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

1.17 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.

1.18 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

1.19 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

1.20 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

1.21 The basic steps of financing include air traffic forecasts, a financial and economic analysis, a financing plan and sources of financing.

1.22 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

1.23 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

1.24 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. Four types of analyses may be of interest:

1) **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;

2) **cost-benefit analysis** to demonstrate financial viability and to identify the investment option that best conforms with the economic goal of maximizing net benefits;

3) **business case study** which is a substantiated argument for a project, a policy or a programme proposal requiring a resource allocation and/or investment, often including a financial commitment. The business case includes a comprehensive assessment of the benefits, costs, risks and financial implications associated with the proposal; and/or

4) **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 Appendix E.

Financing plan

1.25 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.

1.26 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 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

1.27 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.

Direct contributions from governments

1.28 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.

1.29 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.

1.30 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). However, there are also some risks involved in foreign exchange, such as currency fluctuations.

Debt financing

1.31 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 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

1.32 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 reasonable 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 1.7 of this Appendix.

Equity financing

1.33 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

1.34 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.

Appendix G

ASSISTANCE REQUIREMENTS AND TECHNICAL COOPERATION

REFERENCES

ICAO Strategic Objectives
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
Resolution A35-20: Update of the new policy on technical cooperation
Resolution A35-21: Expansion of ICAO technical cooperation activities
Resolution A27-18: Funding for Technical Co-operation Activities

INTRODUCTION

1.1 The planning and implementation of the CNS/ATM systems require cooperation among all partners that have a stake in their success. Assistance requirements of developing States, in particular, need to be addressed. Technical and financial cooperation of the aviation and development financing communities, in coordination with ICAO, will be required worldwide so as to ensure safe and globally harmonized implementation.

ASSISTANCE REQUIREMENTS OF DEVELOPING ICAO CONTRACTING STATES FOR CNS/ATM PLANNING AND IMPLEMENTATION

1.2 In 1994 and 1997, on behalf of the CNS/ATM Systems Implementation Task Force (CASITAF), the Technical Co-operation Bureau conducted an initial survey of States' requirements for assistance in CNS/ATM planning and implementation, through a questionnaire involving the ICAO Regional Offices.

The results of the ICAO surveys confirmed that, while some States were in a position to develop and implement their national CNS/ATM systems plan using their own resources, the majority of States, in particular developing States, require external 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, procurement, installation and commissioning; and
- human resource planning and development.

1.3 Experience gained through ICAO technical cooperation projects over the years and increasing requests from States for ICAO assistance in this area through the Technical Co-operation Programme indicate that this situation is still current.

SOURCES OF ASSISTANCE AND FUNDING

1.4 Satisfying the needs of developing States, not only with regard to the transfer of know-how but also for external financing, is a major task for the international financing community and development partners.

1.5 Global ATM implementation requires supporting regional and national infrastructure and human resources. While certain States are in a position to address their CNS/ATM systems development needs using their own resources, external assistance is required by the vast majority of developing States for providing the infrastructure and qualified human resources needed. 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 infrastructure, and human resources, and to secure the required funding.

1.6 It is expected 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 and human resource development requires the involvement of the aviation industry, development partners and the international financing community, particularly multilateral donors. Interregional and subregional planning and implementation cooperative efforts have the potential to attract financial support from global development financing partners, such as the Bretton Woods institutions, regional organizations and associations, development banks, the private sector, the aviation industry and service providers.

ICAO Objectives Implementation Funding Mechanism

1.7 The ICAO Objectives Implementation Funding Mechanism was established by the ICAO Assembly in 1995 as part of a new policy on ICAO technical cooperation, the objectives of which emphasized the global implementation of SARPs and ANPs, including the CNS/ATM systems. The Assembly encouraged Contracting States to make use of the ICAO Technical Co-operation Programme and to contribute to this new funding mechanism, aimed at consolidating all other funding arrangements. The first meeting of the ALLPIRG/Advisory Group, 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 Funding Mechanism. Development partners, as well as States themselves, may find the Mechanism a suitable channel to provide the necessary support to States in the transition to the CNS/ATM systems.

1.8 The objectives of the ICAO Objectives Implementation Funding 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 linked to ICAO's Strategic Objectives and priority activities in the implementation of SARPs and ANPs, including the implementation of the CNS/ATM systems.

1.9 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.

1.10 A variety of funding modalities exist under the Mechanism to suit the needs of particular donors, and these provide 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.

1.11 Funding and operation of the Mechanism have 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

1.12 ICAO offers technical cooperation in the civil aviation field through its Technical Co-operation Bureau, which was established in 1952. The Technical Co-operation Bureau carries out projects funded by developing States themselves or by various bilateral and multilateral funding institutions, as well as regional organizations, the industry and service providers, among others.

1.13 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.”

1.13 The Organization’s Strategic Objectives for 2005-2010 advocate, inter alia*,* that ICAO develop, coordinate and implement air navigation plans that reduce operational unit cost, facilitate increased traffic and optimize the use of existing and emerging technologies, calling for ICAO to assist States to improve efficiency of aviation operations through technical cooperation programmes.

1.14 With particular regard to the CNS/ATM systems, 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.”

1.15 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 …”.

1.16 The Assembly has reaffirmed that the ICAO Technical Co-operation Programme is a permanent and priority activity of the Organization. It complements the role of the Regular Programme in providing support to States in the effective implementation of SARPs and ANPs, as well as in the development of their civil aviation administration infrastructure and human resources (Assembly Resolution A35-20).

1.17 The Technical Co-operation Programme is implemented through projects that typically provide assistance to recipient administrations in the recruitment of experts in various areas who are assigned, either individually or through sub-contracted consultant firms, to provide technical advice and transfer of know-how; the award of fellowship training abroad to national staff; and in the preparation of technical specifications, tendering, procurement, installation and commissioning of equipment.

Special features of ICAO Technical Cooperation

Recipient States of technical cooperation

1.18 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 executing agency with civil aviation projects that may be funded.” (Assembly Resolution A27-18)

1.19 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.

1.20 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

1.21 The ICAO Assembly has recommended to Contracting States with bilateral or other government-sponsored aid programmes to consider the value of using the ICAO Technical Co-operation Programme 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. (Assembly Resolution A27-18)

1.22 ICAO can assist governments in the selection of equipment, equipment manufacturers (through international tender calls), international experts and consultancy companies as well as existing training establishments, to meet project goals in the most cost-effective manner. ICAO's neutrality allows for the selection of suppliers on a worldwide basis, where required.

1.23 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.

1.24 ICAO will implement projects in close coordination with donors and funding organizations, and in accordance with pre-defined conditions 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.

1.25 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 with 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.

Expansion of ICAO Technical Cooperation

1.26 In furtherance of ICAO objectives, the Assembly, in its Resolution A35-20, expanded the provision of assistance through technical cooperation to non-State entities (public and private) directly involved in civil aviation. The purpose of this Resolution is to include those activities traditionally provided by national civil aviation administrations which are being delegated to third parties, through privatization or other organizational form, taking into account the fact that, under the Chicago Convention, the delegating State shall, nonetheless, continue to have responsibility for the quality of the services provided and their compliance with ICAO SARPs.

1.27 The Assembly also resolved (under Assembly Resolution A35-21) to expand the provision of technical cooperation services, upon request, to non-State entities (public and private) implementing projects in States in the field of civil aviation that aim at enhancing the safety, security and efficiency of international air transport.

Strategies for ICAO technical cooperation in CNS/ATM implementation

1.28 Initial assistance for CNS/ATM was provided to several States from multilateral and bilateral sources, including ICAO, focusing mainly on familiarization, initial transition planning and setting up of pilot projects. Some States and groups of States have since moved to the planning and implementation of the systems or components thereof at the national or regional levels.

1.29 CNS/ATM familiarization projects were implemented by ICAO in the Asia/Pacific and Latin America Regions in 1995 and 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 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.

1.30 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 including extensive training of national personnel and the procurement of equipment to set up the basic infrastructure necessary to implement the CNS/ATM systems. Country-specific, sub-regional and regional technical cooperation projects currently under implementation by ICAO in several countries continue to successfully support the CNS/ATM systems planning and implementation process. National plans have been developed with the assistance of ICAO by most of these countries, or are in the process of review and approval by the respective authorities, ensuring compliance with applicable SARPs and harmonization with regional plans. Through these projects, civil aviation administrations responsible for the transition to CNS/ATM systems have been able to familiarize themselves with the institutional planning tools and develop the necessary expertise, allowing for enhanced coordination at the regional level.

1.31 Human resources development requirements, commensurate with CNS/ATM systems implementation, are being addressed at the national and regional levels 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, basic training carried out through nationally oriented courses, and advanced 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. Training of national staff by manufacturers and suppliers is increasingly carried out under the procurement component of ICAO technical cooperation projects.

1.32 Regional and sub-regional cooperative arrangements among Contracting States managed by ICAO, concerning a homogeneous ATM area or major international traffic flow, allow participating States to closely collaborate in systems planning, procurement, training and implementation. These cooperative arrangements are 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 are considered to have 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 increasing South-to-South cooperation and regional capacity-building.

1.33 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. In order to effectively contribute to the achievement of ICAO's Strategic Objectives, the Technical Co-operation Programme places enhanced emphasis upon the implementation of ICAO's SARPs to the greatest possible extent worldwide, and it has played an increasing role in the implementation of these new air navigation systems, including associated facilities, services and related human resource planning and development.

1.34 To be in a position to better respond to the requirements of States and users, the ICAO Technical Co-operation Programme, which has traditionally assisted developing States through projects funded by the governments themselves, embarked upon the expansion of its resource base by focusing on non-traditional development partners and funding sources, including interregional and regional development banks and financing institutions, and regional organizations and associations, the private sector, the aviation industry and service providers.

1.35 ICAO, through its Technical Co-operation Bureau, 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 the Technical Co-operation Bureau. Funding sources, such as Bretton Woods institutions, regional development banks and industry will continue to be approached to fund CNS/ATM projects.

1.36 Results of 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 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 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.

1.37 Since ICAO's most prominent goal is to provide its Contracting States with assistance in the implementation of SARPs worldwide, the ICAO Technical Co-operation Programme will continue to associate itself with as many CNS/ATM-related civil aviation development efforts as possible, in the ultimate interest of States. As such, it will continue to 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.

Appendix H

ENVIRONMENTAL BENEFITS ASSOCIATED WITH CNS/ATM SYSTEMS IMPLEMENTATION

BACKGROUND

Aviation and the environment

1.1 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.

1.2 Aircraft engines burn fuel, producing emissions that are similar to other emissions resulting from fossil fuel combustion. Although when compared to all sources, aviation is a relatively small direct contributor to greenhouse gas (GHG) emissions, attention is focused on aviation because of its historic growth rate and the projected future growth. In addition, as the majority of aviation emissions occur at higher altitudes (10-12 km), their relative contributions to climate change are commensurately increased due to other ensuing radiative effects from, for example, contrails and enhanced cirrus clouds. These emissions give rise to important environmental concerns regarding their global impact and their effect on local air quality.

1.3 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 *Special Report on Aviation and Global Atmosphere* (1999) of the Intergovernmental Panel on Climate Change (IPCC) 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.

1.4 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.

CAEP

1.5 The ICAO Committee on Aviation Environmental Protection (CAEP), a Technical Committee of the ICAO Council, is the international expertise forum for the study and development of proposals to minimize aviation's effects on the environment. The 35th Assembly declared that "ICAO is conscious of and will continue to take into account the adverse environmental impacts that may be related to civil aviation activity…. In carrying out its responsibilities ICAO will strive to… limit or reduce the impact of aviation greenhouse gas emissions on the global climate." The Assembly also directed the Council to "regularly assess the present and future impact of aircraft noise and aircraft engine emissions…" and "disseminate information on the present and future impact of aircraft noise and aircraft engine emissions…".

Specifically with regard to aircraft communications, navigation, surveillance and air traffic management (CNS/ATM) systems, the Assembly recognized "that substantial fuel savings and emissions reductions can be achieved through improvements in Air Traffic Management (ATM)" and directed the Council "to continue to study policy options to limit or reduce the environmental impact of aircraft engine emissions and to develop concrete proposals…, placing special emphasis on the use of technical solutions…" . (Assembly Resolution A35-5)

1.6 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.

1.7 CAEP has been studying possible means to reduce aircraft engine emissions, including the reduction at source, through operational measures and using market-based options.

Reducing fuel burn through improved operational measures

1.8 Implementation of CNS/ATM systems under the Global Plan 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. These benefits have the potential to deliver improvements such as local air quality. More efficient en-route flight management reduces block fuel requirements which can mean lower thrust setting on take-off. On-route efficiency feeds back to airports with improved sequencing, reduced holding, and better gate and apron management. Collectively, these improvements offer reduced fuel burn and lower levels of pollutants.

1.9 After labour, fuel represents the largest cost component in airline operations. An effective and efficient way of reducing costs is to use less fuel, which has the added benefit of making a difference to the environment. For operational measures, emissions savings come from improvements in air traffic management and other operational procedures. The large majority of these reductions come from CNS/ATM systems implementation, which will allow more direct routings and more efficient conditions such as optimum altitude and speed. Specifically, fuel consumption and emissions can be reduced by route improvements, altitude optimization allowing Reduced Vertical Separation Minimum (RVSM), gate-to-gate efficiency in ground/air management, approach and departure procedures and other factors. Information on these measures has been disseminated through workshops and explained in ICAO Circular 303 *Operational Opportunities to Minimize Fuel Use and Reduce Emissions*.

1.10 Building on Circular 303, an elementary theoretical calculation was made (ICCAIA[1] — February 2006) broadly comparing ATM improvements, which would benefit the entire fleet, versus aircraft technology improvements applied to part of the fleet. The analysis found that the shorter lead-time for introduction of ATM improvements and quicker penetration to benefit all operations resulted in a clear advantage for ATM system improvements. Assuming the same percentage (purely hypothetical) reduction in fuel consumption from both ATM and aircraft technology changes, the study found that between a given improvement in aircraft technology and one of the same magnitude in ATM, there may be a significant difference in cumulated fuel burn reduction effect due to a more rapid deployment potential for the latter (a factor higher than three is mentioned in ICCAIA—Feb 2006, as a result of a very simplistic simulation). It can be noted

1. ICCAIA - International Coordinating Council of Aerospace Industries Associations.

that this analysis was not meant to undermine the importance of aircraft technological progress, rather its intent was to increase awareness and encourage advances towards the most efficient systems approaches fostering homogeneous and consistent development of capabilities relative to ATM and aircraft, ground and airborne systems.

EMISSIONS CALCULATION

1.11 Calculation of aviation emissions is dependent on: the number and type of aircraft operations, the type and efficiency of the aircraft engines, the type of fuel used, the length of flight, the power setting, the time spent at each stage of flight, and the location (altitude) at which exhaust gases are emitted. For CNS/ATM benefit analyses, it is necessary to have data that can reflect the operational changes.

1.12 Depending on the need, there are different levels of analysis possible: order of magnitude, simple consideration of CO_2 based on fuel burn, detailed modeling of all emissions parameters, and variations in between. However, not all methods of calculating fuel burn and emissions provide the specificity necessary to calculate the benefits from implementing changes to air traffic management systems. The following is a discussion of the various analysis options and their potential usefulness in assessing the benefits of implementing CNS/ATM systems. As with any assessment, before the outputs can be used with confidence, it is necessary to consider documented inputs, assumptions and methodology.

1.13 Various entities have considered the emissions benefits of implementing CNS/ATM systems based on an order of magnitude assessment. This type of assessment makes assumptions on the scale of improvements that would come from the implementation of specific ATM system changes. One example that includes this type of analysis is the November 2000 NLR report for IATA entitled *"Operational measures to improve aircraft fuel efficiency and reduce emissions"* (NLR-CR-2000-332). The appropriateness of using an order of magnitude assessment is dependent on the quality of the base data and assumptions, as well as consideration of how the results will be used. With accurate base data and appropriately considered assumptions, an order of magnitude assessment can produce results sufficient for many general information purposes.

Initial CNS/ATM study

1.14 Initiated in 1999, ICAO CAEP conducted a parametric analysis to estimate the emissions benefits of implementing CNS/ATM systems. The parametric model used for the initial study looked at many types of CNS/ATM systems enhancements, including 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.

1.15 The scope of the initial 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. Additional information on this study can be found in CAEP/5-WP/18 and via http://www.faa.gov/opsresearch/Emissions/Emissions_121800_Main.pdf.

Findings of the initial study

1.16 Within the time frame under consideration (1999-2015), global air traffic was expected to increase by approximately 61 per cent according to CAEP's Forecasting and Economic Support Group (FESG). In the same time period, fuel consumption and CO_2 emissions were projected to increase by just 37 per cent. 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.

1.17 The results of this initial 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%

1.18 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.

1.19 Although no further regional analyses of CNS/ATM using the parametric model were conducted due to lack of funding, CAEP had focussed its efforts on data collection, and in further assessment modeling capabilities. In 2003, CAEP issued State letter AN 1/17-03/86, Data Collection for a Study on the Environmental Benefits of CNS/ATM, in order to gather information on CNS/ATM systems initiatives in other regions of the world to allow for expanded modeling to represent a worldwide result. Unfortunately, very little data resulted from this request and, thus, the planned global analysis could not be performed.

CURRENT ACTIVITIES

1.20 Currently CAEP is assessing the use of more sophisticated models for the calculation of aircraft engine emissions throughout the flight path and at global and regional levels. While these models calculate fuel from the entire flight trajectory, not all models might be suitable for estimating the emissions benefits of implementing CNS/ATM systems. The typical distinction on usefulness for CNS/ATM analysis is the ability to capture the difference in flight trajectory before and after implementation. Three models are currently under consideration by CAEP: the Advanced Emission Model (AEM) of EUROCONTROL, AERO2K adopted by the European Commission and the System of Assessing Aviation's Global Emissions (SAGE) of the U.S. Federal Aviation Administration. Given the appropriate inputs, each of these tools is capable of analysing the emissions benefits of implementing CNS/ATM systems.

1.21 CAEP is in the midst of an ongoing effort to ensure that models used by CAEP, both existing and under development, have the capability to analyse trade-offs between the various environmental impacts of technical, operational and market-based measures, and that they encompass, on a more comprehensive basis, all regions of the world. Figure H-1 outlines the methodology steps necessary to conduct a detailed greenhouse gas (GHG) emissions calculation, which could be used for CNS/ATM analyses.

1.22 Whether CAEP undertakes assessments will be dependent on availability of data and resources. CAEP continues to be open to the receipt of the necessary operational data to support the assessment of the environmental benefits of CNS/ATM systems in all ICAO regions, while utilizing available modeling tools, harmonized data sets and methodologies.

1.23 ICAO is exploring the necessary steps for the inclusion of environmental considerations in the business cases (see Appendix E).

1.24 Due to the growth of air traffic, increasing public pressure for the reduction of aviation-related CO_2 can be expected in the upcoming years. ICAO has a leading role in promoting the implementation of measures to minimize or reduce the impact of aviation emissions on climate change and needs to ensure that all measures taken to improve the efficiency of air transport are monitored and reported in terms of environmental savings. ICAO is currently taking the necessary steps to facilitate the reporting of voluntary measures to reduce aviation emissions.

1.25 Since the early 1970's rising traffic volumes and a series of world fuel shortages with the resultant rapid escalation of fuel costs sparked an interest in airspace enhancements and separation reduction initiatives, including Reduced Vertical Separation Minimum (RVSM). The 2 000-ft minimum vertical separation restricted the number of flight levels available. Flight levels (FL) 310, 330, 350, 370, and 390 are flight levels at which aircraft operate most economically. As air traffic increased, the opportunity for aircraft to fly the desired time and fuel-efficient flight levels and routes diminished significantly. Particularly during peak periods, these FLs became congested. In areas characterized by high-density traffic, the air navigation services provider (ANSP) may be required to invoke restrictions that can result in traffic delays and fuel penalties.

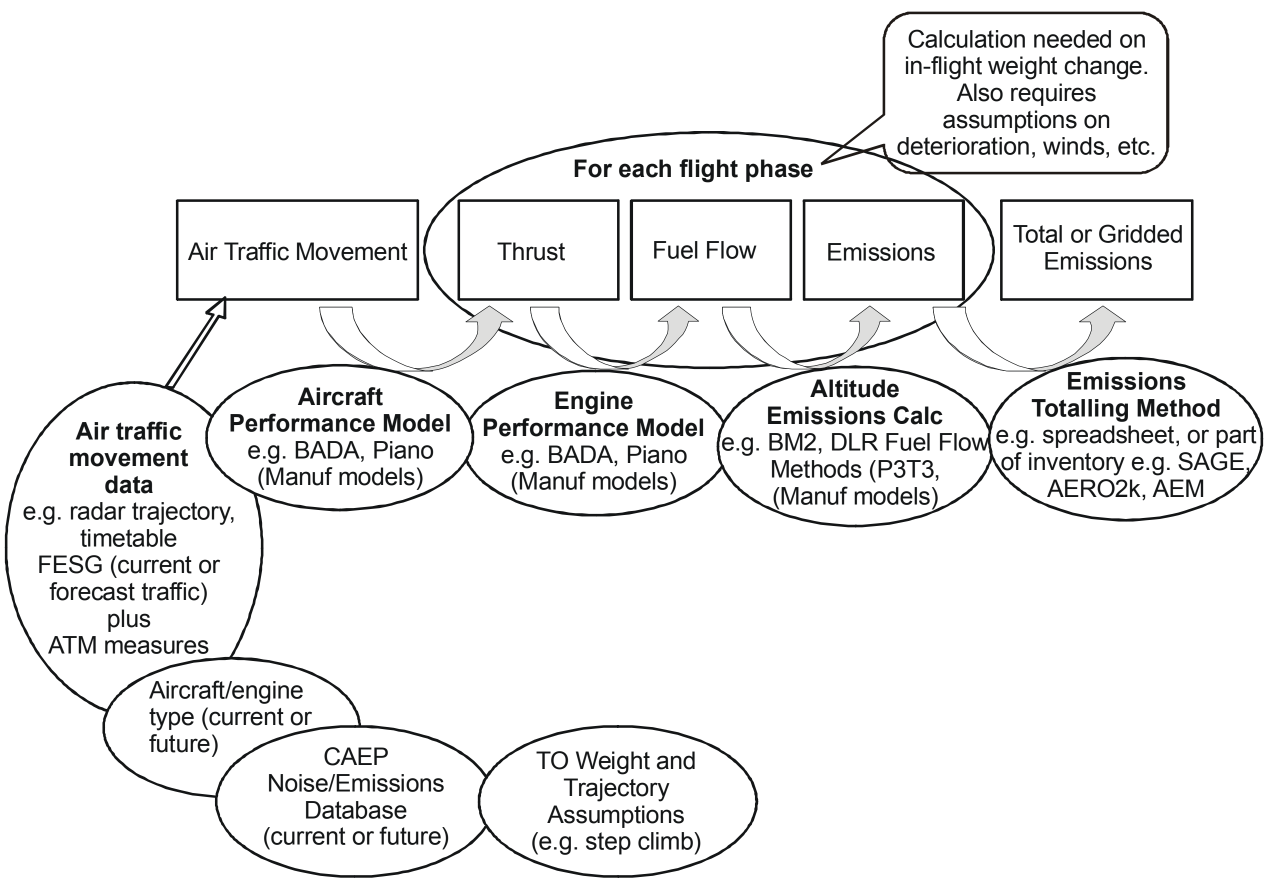

Figure H-1. Outline of GHG methodology

1.26 In response to annually increasing air traffic levels, airspace planners have in coordination with their international counterparts established programmes to implement RVSM as one of the measures to enhance air traffic management and operating efficiency. The status of RVSM implementation has improved significantly in recent years with progressive coverage of more and more oceanic and continental airspaces. By 2006, RVSM was operational in airspaces over Australia, Europe, North America, the North Atlantic Ocean and the portion of the West Atlantic Route System (WATRS) that is in the New York Oceanic Flight Information Region, the South Atlantic, the Pacific Ocean including the South China Sea, the Middle East and South of the Himalayas, facilitating routes from and to Asia as well as from and to the Middle East and Europe.

1.27 As concluded by the fifth meeting of the ALLPIRG/Advisory Group[2], held from 23 to 24 March 2006, ICAO is studying the environmental benefits of the introduction of RVSM, seeking the appropriate support from air navigation services providers that have evaluated the environmental benefits of RVSM with strategic planning instruments or post-implementation assessments.

Regional planning considerations

1.28 Regional planning groups are asked to take environmental factors into consideration when developing CNS/ATM systems implementation plans. The results of environmental analysis can be useful in providing national decision-makers within the various regions with information upon which to base airspace architecture decisions and in providing information on what the aviation industry is doing now to protect the environment in the future.

1.29 Representatives of the PIRGs are encouraged to contact the ICAO Secretariat for additional guidance to evaluate the environmental benefits of planned CNS/ATM systems enhancements. After initial contact with the Secretariat, arrangements must be made to gather the appropriate modeling data for a particular region to begin the modeling effort. The data as described above can be collected from existing databases, from direct interviews between representatives from the regional planning groups and the modelers, or by the development of regional-specific assumptions.

Practical information for States assessing benefits

1.30 As requested by the Planning and Implementation Regional Groups (PIRGs), practical generic “rules of thumb” have been developed that can be used by States to estimate the emissions benefits of implementing CNS/ATM systems. Which method to use will depend on the level of detail and accuracy needed for the outputs and the nature of available input information.

1.31 ***Fuel to emissions conversion*** — When fuel consumption (fuel burn) data are available that show the change from base-case to CNS/ATM system implementation, the most direct assessment of GHG emissions is to use the following CO_2 conversion factor; namely, 3.16 kg CO_2/kg of fuel.

$$CO_2 \text{ Emissions} = \text{Aviation Fuel Consumption} \cdot 3.16$$

Given the global nature of the aviation industry and the tight specification of fuels used, this emissions factor is applicable worldwide and is the basis of the Intergovernmental Panel on Climate Change (IPCC) Tier 1 method (based on total fuel sold). The accuracy of results of using this method is almost entirely dependent on the accuracy of the fuel consumption data.

2. For conclusions, refer to State Letter M7/1-06/62 dated 18 August 2006.

1.32 ***Rules of thumb*** — To gain a "first-order estimate" of the environmental benefits of potential CNS/ATM changes in order to assess which options to carry forward, a less accurate, rough-and-ready method may be all that is necessary. Statistics relating to fuel burn and emissions are critically dependent on aircraft and engine types, operating procedures, air traffic management constraints, passenger and cargo loading, maintenance procedures, fleet utilization and other factors. Without more detailed analysis it is impossible to be specific about the performance of any particular aircraft or airline. **The first order approximation approach used is therefore only intended to provide broad-based information for very general planning and assessment purposes.** The three general estimates provided below are based on common statistics and assumptions and were provided by IATA/ICCAIA. These may be applied more broadly as a "rule of thumb" to obtain order of magnitude estimates[3]:

Average fuel burn per minute of flight = 49 kg

Average fuel burn per nautical mile (NM) of flight = 11 kg

Average additional fuel burn for a change in flight level: see Table 1 in Attachment 1.

1.33 ***Detailed modeling*** — This method is appropriate when accuracy is essential; however, it is resource intensive and relatively complex. This methodology is distinguished by the calculation of fuel burn and emissions throughout the full trajectory of each flight segment using aircraft and engine-specific aerodynamic performance information. To use Tier 3B, sophisticated computer models are required to address all the equipment, performance and trajectory variables and calculations for all flights in a given year. Models used for Tier 3B level can generally specify output in terms of aircraft, engine, airport, region, and global totals, as well as by latitude, longitude, altitude and time, for fuel burn and emissions of carbon dioxide (CO_2), carbon monoxide (CO), unburned hydrocarbons (HC), nitrogen oxides (NOx), water (H_2O), and sulfur oxides (SOx calculated as sulfur dioxide, SO_2). Examples of these tools are listed in paragraph 1.20.

[3] Please see Attachment 1 for more details about how these estimates were derived.

ATTACHMENT 1

CALCULATIONS BEHIND THE FIRST-ORDER ESTIMATES GIVEN IN PARAGRAPH 1.32

1. *Average fuel burn per minute of flight* = 49 kg

This number is derived by dividing the total JET A1 consumption (55 billion USG) by the total of minutes flown (3.4 billion) by all airlines (scheduled and non-scheduled) as per IATA statistics for 2005[4]. For the conversion from USG to kg fuel, a factor 3.0265 (3.7831 * 0.8) was used.

2. *Average fuel burn per nautical mile of flight* = 11 kg

This number is derived from dividing the total JET A1 consumption (55 billion USG) by the total of kilometres flown (27.9 billion) by all airlines, (scheduled and non-scheduled) as per IATA statistics for 2005. For converting km into NM, the definition: 1 NM = 1.852 km was used.

3. *Average additional fuel burn for a change in flight level* (FL)

3.1 *General approach followed*

The fuel penalties resulting from deviations from an assumed optimum altitude are based on average specific range penalties estimations made by Airbus and Boeing, complemented by a short ICCAIA study (ICCAIA-March 2006). The original figures appear in *"Getting to grips with fuel economy",* issue 3 — July 2004 by Airbus (page 39) and "*Fuel Conservation*" — November 2004 by Boeing (page 41). The principle of the ICCAIA study is outlined in the next two paragraphs. The results are shown in Table H-1 and in Figures H-2, H-3 and H-4.

It is important to note that all estimations used and corrections made to derive fuel burn penalties are based on data applicable to the cruise part of the flights and then applied to the overall average fuel consumed over entire flights, which is valid only as a first order approximation, considering that the cruise portion of the flight is the most significant in terms of fuel consumption.

3.2 *Derivation of a fuel burn penalty from a specific range penalty*

Posing by definition of specific range: S = D/F (D = distance in NM, F = Fuel burn in kg)

For the optimum-altitude case: So = D/Fo hence Fo = D/So

For the penalized case (non-optimum-altitude): Sp = D/Fp hence Fp = D/Sp

The fuel penalty in % is: ∆F/F = 100*(Fp-Fo)/Fo = 100*(D/Sp — D/So)*So/D
→ ∆F/F = 100*(So — Sp)/Sp

The specific range penalty by definition is: ∆S/S = 100*(So — Sp)/So
(input in the calculation coming from the Boeing and Airbus reference data) in %

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4. Typically, IATA statistics come from in-house analysis using complementary data from ICAO , OAG, IEA, Eurocontrol, FAA, Boeing, Airbus and others.

Hence:

$\Delta F/F = 100*(\Delta S/S)/(100-\Delta S/S)$

correctly expressed in algebraic terms: $\Delta F/F = -100*(\Delta S/S)/(100+\Delta S/S)$

with $\Delta S < 0$ for a penalty.

This explains why: $|\Delta F/F| > |\Delta S/S|$

Example: deviation altitude -6 000 ft → $\Delta S/S$ = -9.07 (%)→ $\Delta F/F$ = +9.97 (%)→ fuel penalty per hour, not time-corrected: 49*60*0.0997 = 293 kg

3.3 *Speed/Time correction corresponding to an altitude deviation*

A time variation $\Delta t/t$ can be easily derived from the speed variation, based on v = D/t, or t = D/v

We find: $\Delta t/t = -100 (\Delta v/v)/(100+(\Delta v/v))$ in % (1) with $\Delta v/v$ in %

The corrected fuel burn penalty in kg per hour is calculated as:

$\Delta F' = \Delta F * t/tc$ where ΔF is the non-corrected fuel penalty and tc is the corrected time
$tc = t * (1+(\Delta t/t)/100)$

$\Delta F' = \Delta F/(1+(\Delta t/t)/100)$ (2) with $\Delta t/t$ in %

Combining then (1) and (2), we obtain:

$\Delta F' = \Delta F*(1+(\Delta v/v)/100)$ (3) with $\Delta v/v$ in %

(All formulae above to be used algebraically.)

The speed (v) variation (Δv) corresponding to the ambient static temperature (Tamb) change, from $Tamb_1$ to $Tamb_2$, associated with an altitude Z change from Z_1 to Z_2, is calculated as follows:

By definition, True air speed = v = $M_n\sqrt{}$ (gam*R*Tamb) in $m.s^{-1}$ where: M_n = Mach Number (assumed constant in the estimation of the flight level change effect);
gam and R are thermodynamic constants (gam = 1.4 ; R= 287.053 in SI units)

$\Delta v/v = 100 (v_2-v_1)/v_1 = 100 (\sqrt{}(gam*R*Tamb_2 - \sqrt{}(gam*R*Tamb_1))/ \sqrt{}(gam*R*Tamb_1)$ (in %)

→ $\Delta v/v = 100 (\sqrt{}(288.15-1.9812*Z_2)/(288.15-1.9812*Z_1)) - 1$ if Z is the altitude in kft
(standard atmosphere, Z<11 000 m or Z<36 089 ft)

Example:

— Considering an altitude deviation of - 2 000 ft from an assumed optimum FL 330 (33 000 ft) to FL 310 (31 000 ft):

For Z_1 = 33 kft: $Tamb_1$ = 222.77 °K (standard atmosphere) and for Z_2 = 31 kft: $Tamb_2$ = 226.73 °K (std. atm.).

Hence: $\Delta v/v \sim 0.885$ % for -2 000 ft change

→ $\Delta F' = \Delta F*(1.008 85) = 45*1.008 85 = 45$ kg (no significant change)

— For a -6 000 ft deviation from FL 330 to FL 270: $Tamb_2$ = 234.66 °K

→ $\Delta v/v = 100 \sqrt{}(Tamb_2/Tamb_1) - 1 = 2.63\%$

→ $\Delta F' = \Delta F*(1.0263) = 293*1.0263 = 301$ kg

In order to minimize fuel burn, an aircraft should be flown at its optimum altitude. In reality, the optimum altitude changes during flight. In this table, the flight level change is relative to the optimum altitude (referred to as zero ("0")). The average range in fuel burn increase mentioned in ICAO Circular 303[5] is generally in line with the estimated percentages shown in Table H-1. It must be noted that the numbers in Table H-1 are based on the approximate assumption that the cruise phase of the flight is on average representative of the entire flight when making fuel burn penalty estimations.

Table H-1. First-order estimates of average fuel burn penalties for changes in flight level compared to an assumed optimum altitude

FL change	Average S.R.* penalty	Average fuel burn penalty	Average fuel burn penalty per hour**	Average fuel burn penalty per 100 NM
ft	%	%	kg	kg
–6 000	9.1	10.0	301	110
–5 000	6.5	7.0	209	77
–4 000	4.5	4.7	141	52
–3 000	3.0	3.1	92	34
–2 000	1.5	1.5	45	17
–1 000	0.5	0.5	15	6
0	0.0	0.0	0	0
1 000	0.5	0.5	15	6
2 000	1.6	1.6	47	18

*S.R. = Specific Range = distance flown per unit weight of fuel burned ** time-corrected

5. Page 78, paragraph 10.4.

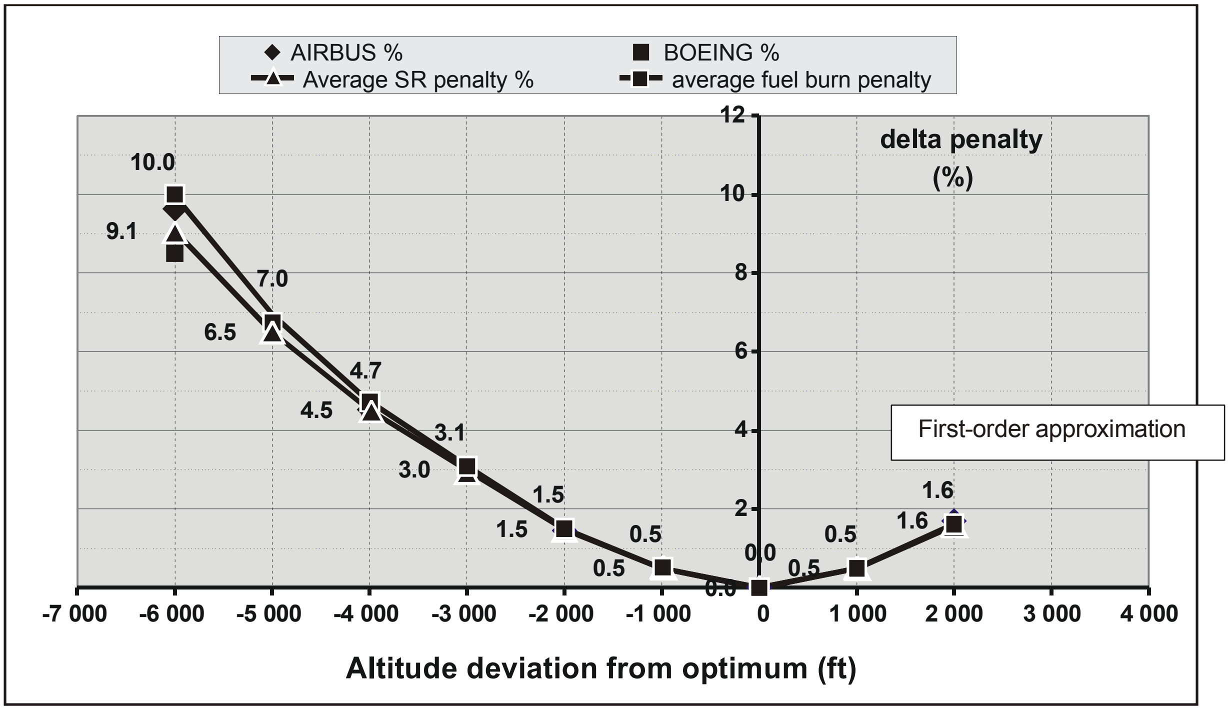

Figure H-2. Specific range and fuel burn penalty for non-optimum altitude

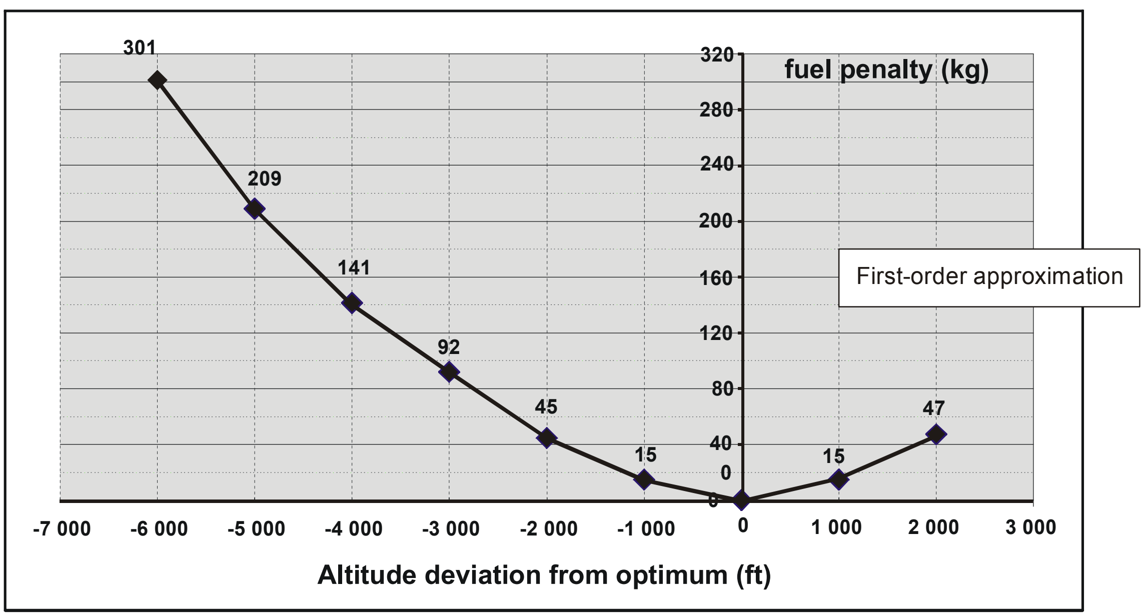

Figure H-3. Average fuel burn penalty/hr (kg)

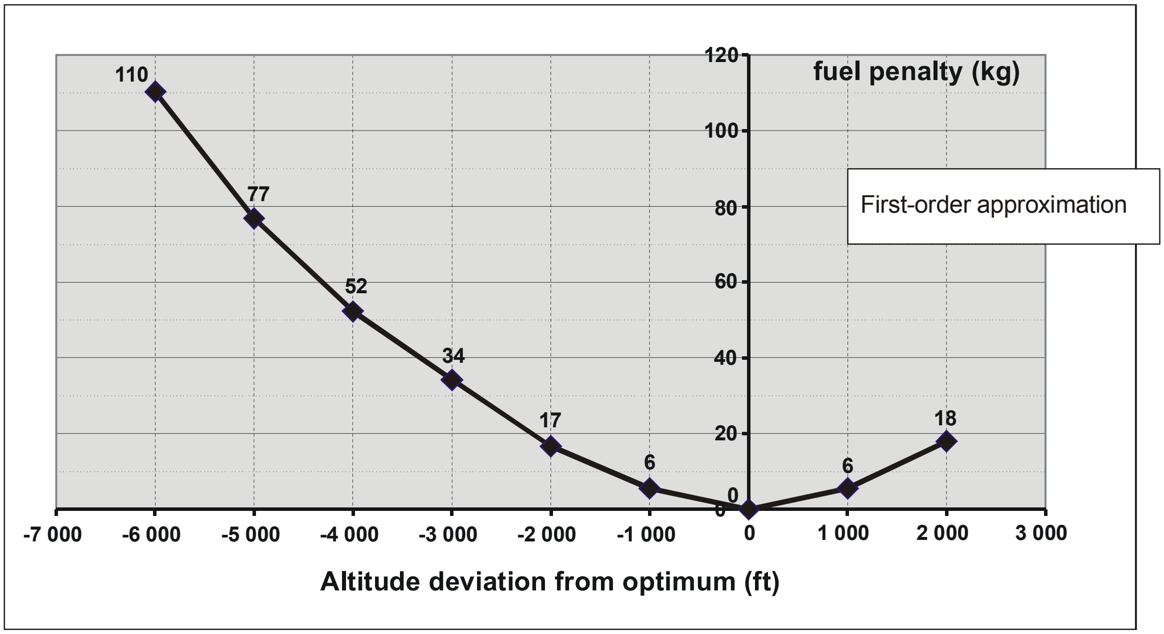

Figure H-4. Average fuel burn penalty/100 NM (kg)

APPENDIX I

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)	Atlantico [1], Canarias, Casablanca, Dakar Oceanic, Recife, Sal Oceanic	Oceanic en route low density in southern part and oceanic high density in northern part	Major traffic flow EUR/SAM
AR2	Atlantic Ocean interface between the AFI, NAT and SAM Regions	Accra, Dakar, Johannesburg Oceanic, Luanda, Sal	Oceanic en route 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 en route/ oceanic low density	Major traffic flow AFI/EUR
AR4	Europe to Southern Africa	Algiers, Beira, Brazzaville, Cape Town, Gaborone, Harare, Johannesburg, Kano, Kinshasa, Lilongwe, Luanda, Lusaka, N'Djamena, Niamey, Tripoli,Tunis, Windhoek	Continental en route low density	Major traffic flow AFI/EUR
AR5	Continental Western Africa including coastal areas	Accra, Dakar, Kano, Ndjamena, Niamey, Roberts	Continental/oceanic low density	Homogeneous area AFI
AR6	Trans-Indian	Antananarivo, Bombay [1], Johannesburg Oceanic, Male [1], Mauritius, Melbourne [1], Seychelles	Oceanic high density	Homogeneous ATM area AFI/ASIA
Asia/Pacific (ASIA/PAC) Regions				
AR1	Asia/Australia and Africa	Bangkok, Chennai, Colombo, Jakarta, Kuala Lumpur, Malé, Melbourne, Mumbai, Singapore, Yangon [and African FIR/UIRs]	Oceanic low density	Major traffic flow AFI/ASIA/MID

Areas (AR)	*Homogeneous ATM areas and major traffic flows/routing areas*	*FIRs involved*	*Type of area covered*	*Remarks*
AR2	Asia (Indonesia north to China, Japan and the Republic of Korea), Australia/New Zealand	Auckland, Bangkok, Beijing, Brisbane, Fukuoka, Guangzhou, Hanoi, Ho-Chi-Minh, Hong Kong, Honiara, Incheon, Jakarta, Kota Kinabulu, Kuala Lumpur, Manila, Melbourne, Nadi, Nauru, Oakland, Phnom-Penh, Port Moresby, Shanghai, Singapore, Taibei, 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, Fukuoka, Guangzhou, Hanoi, Ho-Chi-Minh, Hong Kong, Incheon, Kathmandu, Kunming, Lanzhou, Phnom-Penh, Pyongyang, Shanghai, Shenyang, ,Taibei, Ulaanbaatar, Urumqi, Vientiane, Wuhan, Yangon [and Russian Federation FIRs, and European FIRs]	Continental high density/continental low density	Major traffic flow ASIA/EUR/MID
AR4	Asia and Europe via south of the Himalayas	Bangkok, Colombo, Delhi, Dhaka, Hanoi, Ho-Chi-Minh, Hong Kong, Jakarta, Karachi, Kathmandu, Kota Kinabulu, Kolkata, Kuala Lumpur, Kunming, Lahore, Chennai, Manila, Mumbai, Phnom-Penh, Singapore, Ujung Pandang, Vientiane, Yangon [and Middle East/European FIR/UIRs]	Continental high density/oceanic high 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, Fukuoka, Guangzhou, Hong Kong, Incheon, Pyongyang, Russian Far East of 80E, Shanghai, Shenyang, 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, Fukuoka, Hong Kong and Manila, Oakland (at and north of a line drawn by LAX-HNL-Guam-MNL), Taibei, 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

Areas (AR)	*Homogeneous ATM areas and major traffic flows/routing areas*	*FIRs involved*	*Type of area covered*	*Remarks*
AR9	South-East Asia and China, Republic of Korea, and Japan	Bangkok, Beijing, Fukuoka, Guangzhou, Hanoi, Ho-Chi-Minh, Hong Kong, Jakarta, Kota Kinabulu, Kuala Lumpur, Kunming, Manila, Phnom-Penh, Pyongyang, Shanghai, Shenyang, Singapore, Incheon, Taibei, 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 intraregional major traffic flow
	Buenos Aires — São Paulo/ Rio de Janeiro	Ezeiza, Montevideo, Curitiba, Brasilia	Continental low density	SAM intraregional major traffic flow
	Santiago de Chile — São Paulo/Rio de Janeiro	Santiago, Mendoza, Cordoba, Resistencia, Asunción, Curitiba, Brasilia	Continental low density	SAM intraregional major traffic flow
	São Paulo/Rio de Janeiro Europe	Brasilia, Recife	Continental/oceanic low density	SAM/AFI/EUR interregional major traffic flow
AR2	São Paulo/Rio de Janeiro Miami	Brasilia, Manaus, Maiquetía, Curaçao, Kingston, Santo Domingo, Port-au-Prince, Havana, Miami	Continental/oceanic low density	CAR/SAM/NAM inter- and intraregional major traffic flow
	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 intraregional major traffic flow
AR3	São Paulo/Rio de Janeiro — Lima	Brasilia, Curitiba, La Paz, Lima	Continental low density	SAM intraregional major traffic flow
	São Paulo/Rio de Janeiro — Los Angeles	Brasilia, Porto Velho, Bogotá, Barranquilla, Panama, Central America, México, Mazatlan (Los Angeles)	Continental low density	CAR/SAM/NAM Inter- and interregional major traffic flow
	Mexico — North America	Mexico, Houston, Miami	Continental/oceanic high density	CAR/NAM interregional major traffic flow
AR4	Santiago — Lima — Miami	Ezeza, Resistencia, Cordoba, La Paz, Porto Velho, Bogotá, Barranquilla, Kingston, Havana, Miami	Continental/oceanic low density	CAR/SAM/NAM Inter- and intraregional 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 intraregional major traffic flow

Areas (AR)	*Homogeneous ATM areas and major traffic flows/routing areas*	*FIRs involved*	*Type of area covered*	*Remarks*
	Buenos Aires — Miami	Ezeza, Resistencia, Cordoba, La Paz, Porto Velho, Bogotá, Barranquilla, Kingston, Havana, Miami	Continental/oceanic low density	CAR/SAM/NAM Intra- and interregional major traffic flow
AR5	North of South America — Europe	Guayaquil, Bogotá, Maiquetía, Piarco (NATEUR)	Continental/oceanic low density	SAM/NAT/EUR interregional major traffic flow
AR6	Mexico — Europe	México, Havana, Miami (NATEUR)	Continental/oceanic high density	CAR/NAM/NAT/EUR interregional major traffic flow
	Central America — Europe	Central America, Panama, Kingston, Port-au-Prince, Curaçao, Santo Domingo, San Juan (EUR)	Oceanic high density	CAR/NAT/EUR Intra- and interregional major traffic flow
AR7	Santiago — Lima — Los Angeles	Santiago, Antofagasta, Lima, Guayaquil, Central America, México, Mazatlan	Oceanic low density	CAR/SAM/NAM Intra- and interregional major traffic flow
AR8	South America — South Africa	Ezeiza, Montevideo, Brasilia, Johannesburg (AFI)	Oceanic low density	SAM/AFI interregional major traffic flow
	Santiago de Chile — Easter Island — Papeete (PAC)	Santiago, Easter, Tahiti	Oceanic low density	SAM/PAC interregional 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
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 transpolar 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

Areas (AR)	*Homogeneous ATM areas and major traffic flows/routing areas*	*FIRs involved*	*Type of area covered*	*Remarks*
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 transeastern 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
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 intraregional 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

Areas (AR)	*Homogeneous ATM areas and major traffic flows/routing areas*	*FIRs involved*	*Type of area covered*	*Remarks*
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, Arctic, Anchorage Continental, 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
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	Continental high density Major traffic flow	Major traffic flows in Canadian southern domestic airspace
	Vancouver — Edmonton	Vancouver, Edmonton	Continental high density Major traffic flow	Major traffic flows in Canadian southern domestic airspace
	Edmonton — Calgary	Edmonton	Continental high density Major traffic flow	Major traffic flows in Canadian southern domestic airspace
	Winnipeg — Regina	Winnipeg	Continental high density Major traffic flow	Major traffic flows in Canadian southern domestic airspace
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	Continental high density Major traffic flow	Major traffic flows in US southern domestic airspace
	Boston/New York/Washington DC/Denver — Los Angeles	Boston, New York, Cleveland, Indianapolis, Chicago, Kansas City, Albuquerque, Los Angeles	Continental high density Major traffic flow	Major traffic flows in US southern domestic airspace

Areas (AR)	*Homogeneous ATM areas and major traffic flows/routing areas*	*FIRs involved*	*Type of area covered*	*Remarks*
	Atlanta/Dallas/Phoenix — Los Angeles	Atlanta, Memphis, Fort Worth, Albuquerque, Los Angeles	Continental high density Major traffic flow	Major traffic flows in US southern domestic airspace
NA-17 US East-west flows	Atlanta/Dallas/Phoenix — San Diego	Atlanta, Memphis, Fort Worth, Albuquerque, Los Angeles	Continental high density Major traffic flow	Major traffic flows in US southern domestic airspace
	Miami/Houston/Dallas/ Phoenix — San Diego	Miami, Houston, Fort Worth, Albuquerque, Los Angeles	Continental high density Major traffic flow	Major traffic flows in US southern domestic airspace
	Miami/Houston/Dallas/ Phoenix — Los Angeles	Miami, Houston, Dallas, Albuquerque, Los Angeles	Continental high density Major traffic flow	Major traffic flows in US southern domestic airspace
GM-1	Mexico — North America	Mexico, Houston, Miami; Albuquerque; Los Angeles	Continental/oceanic high density Major traffic flow	CAR/NAM interregional traffic flow
GM-2	Mexico — Europe	Mexico, Havana, Miami (NAT-EUR)	Continental/oceanic high density Major traffic flow	CAR/NAM/NAT/EUR interregional traffic flow

— END —

ICAO TECHNICAL PUBLICATIONS

The following summary gives the status, and also describes in general terms the contents of the various series of technical publications issued by the International Civil Aviation Organization. It does not include specialized publications that do not fall specifically within one of the series, such as the Aeronautical Chart Catalogue *or the* Meteorological Tables for International Air Navigation.

International Standards and Recommended Practices are adopted by the Council in accordance with Articles 54, 37 and 90 of the Convention on International Civil Aviation and are designated, for convenience, as Annexes to the Convention. The uniform application by Contracting States of the specifications contained in the International Standards is recognized as necessary for the safety or regularity of international air navigation while the uniform application of the specifications in the Recommended Practices is regarded as desirable in the interest of safety, regularity or efficiency of international air navigation. Knowledge of any differences between the national regulations or practices of a State and those established by an International Standard is essential to the safety or regularity of international air navigation. In the event of non-compliance with an International Standard, a State has, in fact, an obligation, under Article 38 of the Convention, to notify the Council of any differences. Knowledge of differences from Recommended Practices may also be important for the safety of air navigation and, although the Convention does not impose any obligation with regard thereto, the Council has invited Contracting States to notify such differences in addition to those relating to International Standards.

Procedures for Air Navigation Services (PANS) are approved by the Council for worldwide application. They contain, for the most part, operating procedures regarded as not yet having attained a sufficient degree of maturity for adoption as International Standards and Recommended Practices, as well as material of a more permanent character which is considered too detailed for incorporation in an Annex, or is susceptible to frequent amendment, for which the processes of the Convention would be too cumbersome.

Regional Supplementary Procedures (SUPPS) have a status similar to that of PANS in that they are approved by the Council, but only for application in the respective regions. They are prepared in consolidated form, since certain of the procedures apply to overlapping regions or are common to two or more regions.

The following publications are prepared by authority of the Secretary General in accordance with the principles and policies approved by the Council.

Technical Manuals provide guidance and information in amplification of the International Standards, Recommended Practices and PANS, the implementation of which they are designed to facilitate.

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