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ASIA/PACIFIC AIR NAVIGATION PLANNING AND
IMPLEMENTATION REGIONAL GROUP (APANPIRG/14)
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Agenda Item 3: CNS/ATM Implementation and Related Activities

THE GLOBAL ATM OPERATIONAL CONCEPT

(Presented by the Secretariat)

SUMMARY

The Air Traffic Management Operational Concept Panel (ATMCP) was created by the ICAO Air Navigation Commission to develop and describe, in sufficient clarity and detail, a gate-to-gate air traffic management (ATM) operational concept, that would facilitate the evolutionary implementation of an integrated ATM system. The version of the operational concept attached to this working paper was developed by the ATMCP and presented at ATMCP/1 (18 to 28 March 2002). Following this, the concept was circulated to States and international organizations for review and to provide comments for improvement. The ATMCP then reviewed the comments and updated the operational concept in line with the Commission's instructions. The Commission decided that the operational concept should be presented for assessment to the Eleventh Air Navigation Conference (AN-Conf/11), which is to be held in Montreal from 22 September to 3 October 2003.

Action by the APANPIRG is in paragraph 3.

1. INTRODUCTION

1.1 In follow-up to the Tenth Air Navigation Conference (Montreal, 5 to 20 September 1991), ICAO, at the global level, States, international organizations, and all ICAO planning and implementation regional groups (PIRGs) embarked on communications, navigation, surveillance/air traffic management (CNS/ATM) planning and implementation programmes intended to improve aviation operations by making use of CNS/ATM technologies. However, it was recognized that technology was not an end in itself, and that a comprehensive concept of an integrated and global ATM system, based on clearly-established requirements, was needed. This concept, in turn, would form the basis for the coordinated implementation of CNS/ATM technologies.

1.2 To develop an ATM operational concept, the ICAO Air Navigation Commission, on 12 March 1998, agreed to the establishment of the Air Traffic Management Operational Concept Panel (ATMCP) to undertake specific studies with a view to developing Standards and Recommended Practices (SARPs), procedures and, where appropriate, suitable guidance material necessary for the evolutionary implementation of an integrated air traffic management system.

1.3 The ATMCP was established with a primary work programme element of developing and describing, in sufficient clarity and detail, a gate-to-gate ATM operational concept that would facilitate the evolutionary implementation of a seamless, global ATM system. The work programme also required that the ATM operational concept:

a) be visionary in scope;

b) not be limited by the present level of technology;

c) lead to realization of all the benefits expected from CNS/ATM systems; and

d) provide the basis for cost-benefit analyses associated with the introduction of ATM systems.

1.4 The operational concept contained in the Appendix addresses the critical element of the work programme described above. The operational concept presents the results of progress achieved by the ATMCP toward development of a vision of an integrated, harmonized and interoperable ATM system. This vision, presented in the form of an operational concept, was presented to the Commission in follow-up of the first meeting of the ATMCP (18 to 28 March 2002). After the Commission's review, the operational concept was circulated to States and international organizations for assessment and to make recommendations for improvement.

1.5 The comments received from States and international organizations were reviewed by the ATMCP in accordance with the instructions of the Commission. This led to several changes. The Commission then reviewed the revised operational concept and the way in which the ATMCP acted on each of the comments and agreed that the concept should be presented to the Conference for assessment. The Commission agreed to take further action on the ATM operational concept on the basis of the results of the Conference.

2. THE GLOBAL ATM OPERATIONAL CONCEPT

Introduction

2.1 Early in its work, the ATMCP recalled Article 1 to the Convention on International Civil Aviation dealing with sovereignty. In this context, the operational concept clearly states that global implementation of a seamless ATM system through the provision of CNS/ATM facilities and services shall neither infringe nor impose restrictions upon States' sovereignty, authority or responsibility in the control of air navigation. Therefore, even though the operational concept envisages airspace that is organized globally, it acknowledges sovereignty.

2.2 The planning horizon used for development of the operational concept is up to and beyond the year 2025. The baseline against which the significance of the changes proposed in the operational concept may be measured is the global ATM environment in the year 2000.

2.3 In progressing its work, the ATMCP was unanimous that safety must continue to be the highest priority in planning and implementation of the future ATM system and the role of the ATM system in enhancing safety must be fully realized. At the same time, the ATMCP agreed that recognition of the ATM community's expectations of the future ATM system would be fundamental to the acceptance of the operational concept.

2.4 While the operational concept is considered visionary, many of the current practices and processes will continue to exist through the planning horizon. In this sense, the operational concept document should be seen as evolutionary. Therefore, nothing precludes immediate movement toward implementation of parts of the concept where this is appropriate.

2.5 The operational concept was developed, to the greatest extent possible, in a technology-independent manner. This was done on the basis that within a planning horizon of more than twenty years, much of the technology that exists or is in development today may change or cease to exist.

2.6 Emerging technologies are capable of expanding the possibilities for more efficient and environmentally sustainable flight operations by supporting a variety of system designs and implementation options and configurations. The operational concept recognizes that technology alone is not a solution unto itself. The implementations of the various CNS/ATM technologies must be based on well-developed plans that take into account the specific requirements and objectives of ATM.

Scope of the operational concept

2.7 An operational concept is a statement of "what" is envisaged. It asks and answers the question of what outcomes are required in the case of the ATM system of the future. It is a vision statement. It is not a technical manual or blueprint nor does it detail "how" the concept elements will be enabled; that lies in a lower document in the hierarchical structure, which may include concepts of operation or use, technical standards and strategic plans.

2.8 The operational concept describes the services that will be required to operate the global air traffic system up to and beyond 2025. It addresses what is needed to increase user flexibility and maximize operating efficiencies in order to increase system capacity and improve safety levels in the future ATM system.

Scalability and adaptability

2.9 In many areas, simple solutions based on regional harmonization or cooperation across homogeneous areas may provide satisfactory short- or medium-term responses to the requirements of this operational concept, while in other areas, sophisticated ATM systems may be required.

Expected changes

2.10 The operational concept outlines a range of conceptual changes that will evolve through the planning horizon. Key to the philosophy adopted within the operational concept is the notion of global information utilization, management and interchange. This is seen as the enabler of significant change in the roles of all participants within the ATM system which should then facilitate enhancements in safety, economy and efficiency across the ATM system. It is envisaged that this goal will be supported by evolution to a holistic, cooperative and collaborative decision-making environment, where the expectations of the members of the ATM community will be balanced to achieve the best outcome and in line with the ATM community's expectation of "equity and access".

2.11 The ATM environment is driven by safety and increasingly by commercial or personal outcome expectations. While there are standards in place for global interoperability, many States' systems have evolved within a standards framework that sustains only their individual requirements; however, they now struggle or fail to meet the ever-growing user expectations of global harmonization and interoperability. These limitations are outlined in the operational concept.

Benefits

2.12 The ATM operational concept seeks to bring benefits to the international civil aviation community. From an airspace user perspective, greater equity in airspace access, greater access to timely and meaningful information for decision support and more autonomy in decision-making including conflict management, will provide the opportunity to better deliver business and personal outcomes, within an appropriate safety framework. In particular, system harmonization and integration will provide high levels of assurance of predictability to airline operators and their customers.

2.13 From a service provider perspective, including that of airport operators, the ability to operate within an information-rich environment, with real-time data, as well as system trend and predictive data, fused with a range of automated decision-support or decision-making tools, will enable optimization of services to airspace users.

2.14 From a regulator perspective, safety systems are envisaged to be robust and open, allowing safety not only to be more easily measured and monitored, but also compared and integrated on a global basis.

Concept components

2.15 This operational concept defines seven "concept components". These can be seen as building blocks, or services, that are integrated to form the ATM system. They are: airspace organization and management, aerodrome operations, demand and capacity balancing, traffic synchronization, conflict management, airspace user operations, and ATM service delivery management. The "glue" that binds these components together is the management, utilization and transmission of data and information, generically referred to in the operational concept as information management. These seven components should be seen as being integrated into one system, and not as independent elements.

Common themes and guiding principles

2.16 The ATM system is based on the provision of services. This service-based framework considers all resources, inter alia, airspace, aerodromes, aircraft, humans, etc. to be part of the ATM system. The primary functions of the ATM system will enable flight from/to an aerodrome into airspace, safely separated from hazards, within capacity limits, making optimum use of all system resources. The description of the concept components is based on realistic expectations of human capabilities and ATM infrastructure at any particular time in the evolution to the ATM system described by this operational concept and is independent of reference to any specific technology.

Pace of change

2.17 The operational concept describes the components and, in general terms, their interdependencies, in a global sense. However, the concept also recognizes that reaching the “end-state” cannot be achieved by revolution — rather, it will be an evolutionary process, with the ultimate goal of global harmonization not later than the concept horizon of 2025. This allows States and regions to plan the significant investments that will need to be made, and the time frame for those investments, in a collaborative decision-making environment, and within a framework of safety and business case.

Differing regional expectations

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

Regional coordination

2.19 Recognizing that not all States or regions can be expected to immediately implement the ATM system described in this concept, the operational concept contains details on an expected planning and evolutionary process within the ICAO framework.

2.20 The implementation of the concept is provided for by strategic plans, inter alia, the *Global Air Navigation Plan for CNS/ATM Systems* (Global Plan, Doc 9750), regional plans and State implementation plans, which also describe the progressive intermediate steps toward that goal. The plans of all States need to be aligned to ensure, to the greatest extent possible, that solutions are internationally harmonized and integrated and do not unnecessarily impose multiple requirements for equipment carriage in the air or for a proliferation of ground equipment requirements.

Future work

2.21 The operational concept provides the vision to achieve an interoperable air traffic management system. The development and eventual implementation of such a system requires a multitude of design, specification, planning and assessment activities. This process began with the conception of an operational concept and should progress through the various levels. As part of its future work, there are plans to develop transition strategies and ATM requirements which will lead to development of SARPs and Procedures for Air Navigation Services (PANS) as well as changes to the Global Plan. Regional air navigation plans will also be amended to reflect the changing requirements for facilities and services as these are agreed to. This body of work will guide development and implementation of the global ATM system.

2.22 The operational concept and the future work toward implementation of a system based on the concept must have a strong performance orientation in order to ensure that expectations are being met and that, as systems are increasingly integrated and new operational procedures are introduced, the system will continue to achieve agreed levels of safety. Therefore, the operational concept addresses ATM system performance and safety management. Further work on measuring performance must therefore be undertaken. This is addressed under Agenda Item 3 of the Conference.

Conclusion

2.23 The operational concept provides a vision that will allow States and regions to align their planning processes, allow system solution engineering to be directed toward a harmonized and interoperable outcome, allow airspace users and service providers to share data and information to best mutual outcome, and enhance levels of safety, economy and efficiency, for the good of all members of the ATM community.

3. ACTION BY APANPIRG

3.1 The meeting is invited to note, in the Appendix to this paper, the global ATM operational concept which will be presented to AN-Conf/11 for its review and assessment.

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APPENDIX

ATM OPERATIONAL CONCEPT DOCUMENT

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. In every region of the world, States depend on the aviation industry to maintain or stimulate economic growth and to assist in the provision of essential services to local communities. In this light, civil aviation can be seen as a significant contributor to the overall well-being and economic vitality of individual nations as well as to the world in general. Because of the continued growth in civil aviation, in many places, demand often exceeds the available capacity of the air navigation system to accommodate air traffic, resulting in significant negative consequences not only to the aviation industry, but also to general economic health. 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 maximum use to be made of enhanced capabilities provided by technical advances.

In the 1980's, the ICAO Council considered the steady growth of international civil aviation, taking into account the emerging technologies, and determined that a thorough assessment and analysis of procedures and technologies serving civil aviation was in order. It was generally recognized at the time that the existing approach to the provision of air traffic services (ATS) and the air navigation system was limiting continued aviation growth and constraining improvements in safety, efficiency and regularity. In 1983, the ICAO Council established the Special Committee on Future Air Navigation Systems (FANS) to develop recommendations for the future development of air navigation for civil aviation over a period of the order of twenty-five years. In 1991, a second FANS Committee was established to monitor and coordinate transition planning for the future air navigation system. In September 1991, the Tenth Air Navigation Conference endorsed the FANS Concept. After acceptance by the ICAO Council, it came to be known as "communications, navigation, and surveillance/air traffic management (CNS/ATM) systems."

In order to progress implementation of CNS/ATM systems, a plan of action was needed. The first such effort was the *Global Co-ordinated Plan for Transition to ICAO CNS/ATM Systems* (Global Co-ordinated Plan). In 1996, the ICAO Council determined that CNS/ATM systems had matured and a more concrete plan was needed which would include all developments and possible technical solutions, while putting the focus on regional implementation. In light of this, ICAO revised the Global Coordinated Plan as a "dynamic" document, comprising technical, operational, economic, environmental, financial, legal and institutional elements, also offering practical guidance and advice to regional planning groups and States on implementation and funding strategies. Hence, the revised document, now 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.

In the intervening years since the FANS Committees completed their work, several States and all ICAO regions embarked on ATM 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 ATM system, based on clearly-established operational requirements, was needed. This 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 operational concept contained herein, is intended to guide the implementation of CNS/ATM technology by providing a description of how the emerging and future ATM system should operate. This, in turn, will assist the aviation community to transition from the air traffic control environment of the 20th century to the integrated and collaborative air traffic management system needed to meet aviation's needs in the 21st century. This effort should be seen as the next step in an evolutionary process that began with the FANS Concept — the goal being an integrated, global ATM system. This document presents the operational concept that is intended to meet the needs of the ATM community (Appendix A provides a description of the ATM community) into the foreseeable future. Explanation of terms used specifically for describing the operational concept have been placed in Appendix B.

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Chapter 1

GENERAL

1.1 ATM operational concept

1.1.1 The global air traffic management (ATM) operational concept presents the ICAO vision for an integrated, harmonized and globally interoperable, ATM system. The planning horizon is up to and beyond the year 2025. The baseline against which the significance of the changes proposed in the operational concept may be measured is the global ATM environment in the year 2000.

Vision Statement

To achieve an interoperable global air traffic management system for all users during all phases of flight that meets agreed to levels of safety, provides for optimum economic operations, is environmentally sustainable, and meets national security requirements.

1.1.2 While the operational concept is visionary and even challenging, many of the current practices and processes will continue to exist through the planning horizon. In this sense, the operational concept document should be seen as evolutionary.

1.1.3 A key point to note is that the operational concept, to the greatest extent possible, is independent of technology; that is, it recognizes that within a planning horizon of more than twenty years, much of the technology that exists or is in development today may change or cease to exist. This operational concept has therefore been developed to stand the test of time.

Air Traffic Management

Air traffic management is the dynamic, integrated management of air traffic and airspace — safely, economically, and efficiently — through the provision of facilities and seamless services in collaboration with all parties.

1.2 Operational concept and the ATM system

1.2.1 An operational concept is a statement of "what" is envisaged. It asks and answers the question of what outcomes are required in the case of the ATM system of the future. It is a vision statement. It is not a technical manual or blueprint, nor does it detail "how" things will be enabled; that lies in a lower document in the hierarchy, which may include concepts of operation or use, technical standards and strategic plans.

1.2.2 The ATM system is a system that provides ATM through the collaborative integration of humans, information, technology, facilities and services, supported by air, ground and/or space-based communications, navigation and surveillance.

1.3 Scope of the concept

1.3.1 This operational concept is a description of the manner in which the ATM system will deliver services and benefits to airspace users by the year 2025. The operational concept details how ATM will act directly on the flight trajectory of a manned or unmanned vehicle during all phases of flight and the interaction of that flight trajectory with any hazard.

Scope

This air traffic management operational concept describes the services that will be required to operate the global air traffic system up to and beyond 2025. The operational concept addresses ***what*** *is needed to increase user flexibility and maximize operating efficiencies in order to increase system capacity and improve safety levels in the future air traffic management system*.

1.4 Guiding principles

1.4.1 The ATM system is based on the provision of services. This service-based framework considers all resources, *inter alia,* airspace, aerodromes, aircraft, humans, etc. to be part of the ATM system. The primary functions of the ATM system will enable flight from/to an aerodrome into airspace, safely separated from hazards, within capacity limits, making optimum use of all system resources. The description of the concept components is based on realistic expectations of human capabilities and ATM infrastructure at any particular time in the evolution to the ATM system described by this operational concept, and is independent of reference to any specific technology. Based on these considerations the elements are predicated on these guiding principles:

Guiding Principles

Safety. The attainment of a safe system is the highest priority in air traffic management and, a comprehensive process for safety management is implemented that enables the ATM community to achieve efficient and effective outcomes.

Human. The human will play an essential — and where necessary, central — role in the global ATM system. The human is responsible for managing the system, monitoring its performance, and intervening, when necessary, to ensure the desired system outcome. Due consideration of human factors must be given in all aspects of the system.

Technology. The ATM operational concept addresses the functions needed for ATM without reference to any specific technology and is open to new technology. Surveillance, navigation and communication systems, and advanced information management technology, are used to functionally combine the ground-based and airborne system elements into a fully integrated, interoperable, and robust ATM system. This allows flexibility across regions, homogeneous areas or major traffic flows to meet the requirements of the concept.

Information. The ATM community will depend extensively on the provision of timely, relevant, accurate, accredited and quality-assured information to collaborate and to make informed decisions. When shared on a system-wide basis, information will allow the ATM community to conduct its business and operations in a safe and efficient manner.

Collaboration. The ATM system is characterised by strategic and tactical collaboration in which the appropriate members of the ATM community participate in the definition of the types and levels of service. Equally important, the ATM community collaborates to maximize system efficiency by sharing information leading to dynamic and flexible decision-making.

Continuity. The realization of the concept requires contingency measures to provide maximum continuity of service in the face of major outages, natural disasters, civil unrest, security threats, or other unusual circumstances.

1.5 Drivers for change

1.5.1 The ATM environment, like so many other environments today, is driven by safety and increasingly by commercial or personal outcome expectations. While there are standards in place for global interoperability, many States' systems have evolved within a standards framework to levels that are able to sustain their individual requirements; however, they now struggle or fail to meet the ever-growing user expectations of global harmonization and interoperability. There is no doubt that the ATM system of the year 2000 had many limitations, and these are outlined in Appendix C.

1.5.2 In the year 2000, a range of factors, including cost, efficiency, safety and national interest, drove change in the ATM system. Now, however, the driver for change must be ATM user expectations, within a framework of safety case, cost/benefit analysis and business case. The operational concept identifies a range of user expectations; however, it is recognized that within the planning horizon, the set of solutions to provide expected benefits may change, and this will be identified and implemented through the safety and business case process.

1.5.3 The ATM community's expectations should guide the development of the future ATM system. The ATM operational concept will guide the implementation of specific ATM technology solutions. It is crucial that the evolution to the global ATM system be driven by the need to meet the expectations of the ATM community and enabled by the appropriate technologies. These expectations are further described in Appendix D.

1.6 Expected benefits

1.6.1 This ATM operational concept seeks to derive benefits for all members of the ATM community.

1.6.2 From an airspace user perspective, greater equity in airspace access, greater access to timely and meaningful information for decision support and more autonomy in decision-making including conflict management, will provide the opportunity to better deliver business and individual outcomes, within an appropriate safety framework.

1.6.3 From a service provider perspective, including that of airport operators the ability to operate within an information-rich environment, with real-time data, as well as system trend and predictive data, fused with a range of automated decision-support or decision-making tools, will enable optimization of services to airspace users.

1.6.4 From a regulator perspective, safety systems will be robust and open, allowing safety not only to be more easily measured and monitored, but also compared and integrated on a global basis not for its own sake, but as a platform for continuous improvement.

1.6.5 These expected benefits are described in Appendix E.

1.7 ATM system performance

1.7.1 Members of the ATM community will have differing performance demands of the system. All will have either an explicit, or implicit expectation of safety; although in the year 2000, this was difficult to measure and/or assure. Some will have explicit economic expectations, others efficiency and predictability. For optimum system performance, each of these sometimes competing expectations will need to be balanced. Furthermore, explicit safety outcomes will need to be met and demonstrated. The operational concept outlines a total system performance framework, including a system safety approach which will support both the “end-state” concept, and the various evolutions to that “end-state.” A more detailed description of ATM system performance is located in Appendix F.

1.8 Concept components

1.8.1 This operational concept defines seven interdependent concept components that are integrated to form the future ATM system. They comprise Airspace Organization and Management, Aerodrome Operations, Demand and Capacity Balancing, Traffic Synchronization, Conflict Management, Airspace User Operations, and ATM Service Delivery Management. The ordering of these components implies no priority. The management, utilization and transmission of data and information are vital to the proper functioning of these components. Detailed explanations of these concept components are described in Chapter 2.

1.9 Significant changes

1.9.1 This operational concept outlines a range of conceptual changes that will evolve through the planning horizon. Key to the philosophy adopted within the operational concept is the notion of global information utilization, management and interchange and with that, an enabling, in an evolutionary way, of significant change in the roles of all participants within the ATM system, thereby facilitating enhancements in safety, economy and efficiency across the system. This philosophy is supported in large part by evolution to a holistic, cooperative and collaborative decision-making environment, where the diverging expectations and interests of all members of the ATM community are balanced to achieve equity and access.

1.9.2 Air Traffic Management (ATM) considers the trajectory of a manned or unmanned vehicle during all phases of flight and manages the interaction of that trajectory with other trajectories or hazards to achieve the optimum system outcome, with minimal deviation from the user-requested flight trajectory, whenever possible.

1.10 Evolution to the operational concept

1.10.1 The operational concept describes the components, and in general terms, their interdependencies, in a global sense. However, the concept also recognizes that reaching the "end-state" cannot be achieved by revolution; rather, it will be an evolutionary process, with an ultimate goal of global harmonization not later than the concept horizon of 2025. This allows States, regions and homogeneous areas to plan the significant investments that will need to be made, and the timeframe for those investments, in a collaborative decision-making environment within a framework of safety and business case. The ATM operational concept also provides the basis from which the ATM operational requirements, objectives and benefits will be derived, thereby providing the foundation for the development of regional and national ATM implementation plans. This evolution is described in more detail in Appendix G and the planning process is described in more detail in Appendix H.

1.11 Scalability and adaptability

1.11.1 The operational concept is adaptable to the operational environment of all States and regions, and is scalable to meet their specific needs. This recognizes the fact that while there are urgent requirements to implement ATM changes to meet a range of needs, *inter alia*, the growing traffic demands in certain areas, or a lack of infrastructure in other areas, the appropriate solutions may differ.

1.11.2 In many areas, simple solutions based on regional harmonization or cooperation across homogeneous areas may provide satisfactory short or medium term responses to the requirements of this concept document, while in other areas, sophisticated ATM systems may be required.

1.12 Different regional expectations

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

1.13 Regional coordination

1.13.1 Recognizing that not all States or regions can move immediately to the ATM system described in this concept, the operational concept contains details on an expected planning and evolutionary process, within the ICAO framework.

1.13.2 The implementation of the concept is provided for by strategic plans, *inter alia,* the Global Air Navigation Plan for CNS/ATM Systems, regional plans and state implementation plans, which also describe the progressive intermediate steps toward that goal. The plans of all States need to be aligned to ensure, to the greatest extent possible, that solutions are internationally harmonized and integrated, and do not unnecessarily impose multiple equipment carriage requirements in the air components of the ATM system, or multiple systems on the ground.

1.14 Scenario development

1.14.1 To better understand the interactions of the ATM components in the future, it is necessary to provide some illustrative examples on how the ATM components may be applied consistent with the concept. One particular interpretation has been developed and can be found in Appendix I.

Chapter 2

ATM OPERATIONAL CONCEPT COMPONENTS

2.1 Introduction to the ATM concept components

2.1.1 The ATM system will be based on the provision of integrated services. However, to better describe how these services will be delivered, seven concept components, together with their expected key conceptual changes, are first described in capsule form and further elaborated upon in Sections 2.2 to 2.8 in this chapter. In addition to the seven concept components, Section 2.9 on information services describes the exchange and management of information used by the different processes and services. The ATM system needs to be disaggregated to understand the sometimes complex interrelationships between its components. The ATM system cannot, however, function without any of its components which must be integrated. The separate components form one system. Figure 2-1 depicts the interrelationship of the system components and the convergence into a single system.

2.1.2 Airspace organization and management

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

a) all airspace will be the concern of ATM and will be a useable resource;

b) airspace management will be dynamic and flexible;

c) any restriction on the use of any particular volume of airspace will be considered transitory; and

d) all airspace will be managed flexibly. Airspace boundaries will be adjusted to particular traffic flows and should not be constrained by national or facility boundaries.

2.1.3 Aerodrome operations

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

a) runway occupancy time will be reduced;

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

c) precise surface guidance to and from a runway will be required in all conditions; and

d) the position (to an appropriate level of accuracy) and intent of all vehicles and aircraft operating on the manoeuvring and movement areas will be known and available to the appropriate ATM community members.

2.1.4 Demand and capacity balancing

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

a) through collaborative decision-making at the strategic stage, assets will be optimized to maximize throughput thus providing a basis for predictable allocation and scheduling;

b) through collaborative decision-making, when possible, at the pre-tactical stage, adjustments will be made to assets, resource allocations, projected trajectories, airspace organization, and allocation of entry/exit times for aerodromes and airspace volumes to mitigate any imbalance; and

c) at the tactical stage, actions will include dynamic adjustments to the organization of airspace to balance capacity; dynamic changes to the entry/exit times for aerodromes and airspace volumes; and adjustments to the schedule by the users.

2.1.5 Traffic synchronization

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

a) there will be dynamic 4-D trajectory control and negotiated conflict-free trajectories;

b) chokepoints will be eliminated; and

c) optimization of traffic sequencing will achieve maximization of runway throughput.

2.1.6 Airspace user operations

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

a) accommodation of mixed capabilities and worldwide implementation needs will be addressed to enhance safety and efficiency;

b) relevant ATM data will be fused for an airspace user's general, tactical and strategic situational awareness and conflict management;

c) relevant airspace user operational information will be made available to the ATM system;

d) individual aircraft performance, flight conditions, and available ATM resources will allow dynamically-optimised 4-D trajectory planning;

e) collaborative decision-making will ensure that aircraft and airspace user system design impacts on ATM are taken into account in a timely manner; and

f) aircraft should be designed with the ATM system as a key consideration.

2.1.7 Conflict management

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

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

a) strategic conflict management will reduce the need for separation provision to a designed level;

b) the ATM system will minimize restrictions to user operations; therefore, the pre-determined separator will be the airspace user, unless safety or ATM system design requires a separation provision service;

c) the role of separator may be delegated, but such delegations will be temporary;

d) in the development of separation modes, separation provision intervention capability must be considered;

e) the conflict horizon will be extended as far as procedures and information permit; and

f) collision avoidance systems are part of ATM safety management, but are not included in determining the calculated level of safety required for separation provision.

2.1.8 ATM service delivery management

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

a) services to be delivered by the ATM service delivery management component will be established on an as-required basis subject to ATM system design. Where services are established they will be provided on an on-request basis;

b) ATM system design will be determined by collaborative decision-making and system-wide safety and business cases;

c) services will be delivered by the ATM service delivery management component through collaborative decision-making, balance and optimise user-requested trajectories to achieve the ATM community's expectation; and

d) management by trajectory will involve the development of an agreement that extends through all the physical phases of the flight.

2.1.8.2 The seven ATM concept components introduced above are described in more detail as follows.

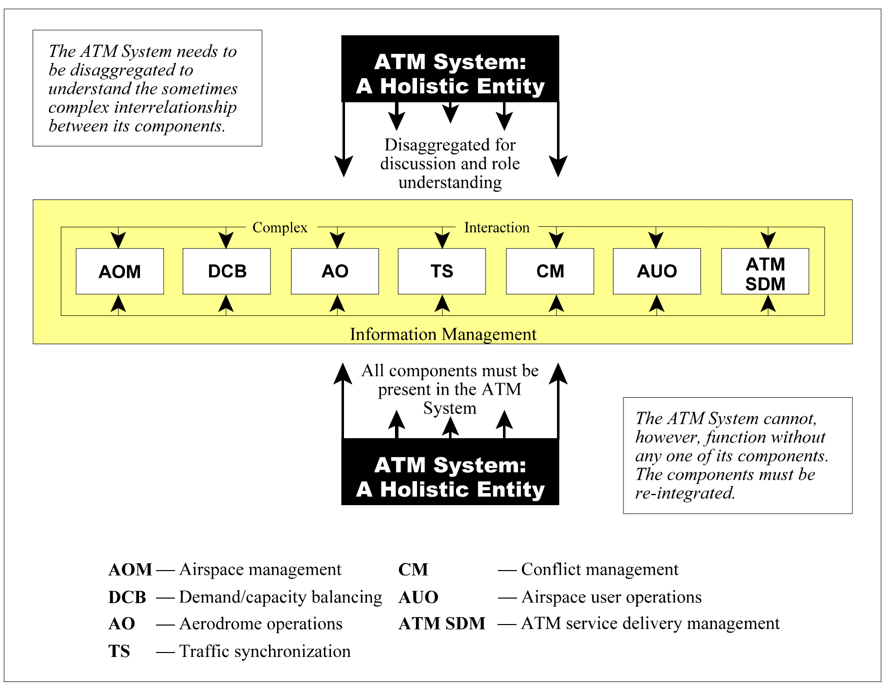

Figure 2-1

2.2 Airspace organization and management

2.2.1 All airspace will be the concern of ATM and will be a useable resource. The organization, the flexible allocation and the use of airspace will be based on the principles of access and equity. On this basis, any restriction on the use of any particular volume of airspace will be considered transitory. The airspace will be organized and managed in a manner that will accommodate all current and potential new uses of airspace, *inter alia*, unmanned airborne vehicles, and transiting space vehicles.

2.2.2 While acknowledging sovereignty, airspace will be organized globally. Homogeneous ATM areas and/or routing areas will be kept to a minimum and consideration will be given to consolidating adjacent areas. The concerned members of the ATM community will undertake strategic planning for any defined area. The ATM service provider managing that airspace will effect tactical changes in specific airspace.

2.2.3 The coordinated planning between adjacent areas will be conducted with the objective of achieving a single airspace continuum. The airspace within that continuum will be free of operational discontinuities and inconsistencies. Airspace will be organized to accommodate the needs of the different types of users on a timely basis. Transition between areas will be transparent to the users at all times.

2.2.4 Airspace organization and management will provide the first layer of conflict management. Effective airspace organization and management will enhance the ability of the ATM service provider and airspace users to accomplish conflict management and also increase ATM system safety, capacity and efficiency.

2.2.5 Airspace organization

2.2.5.1 The airspace organization function will provide the strategies, rules and procedures, by which the airspace will be structured to accommodate the different types of air activity, volume of traffic, and differing levels of service and rules of conduct. The principles of organization will be applicable from the most complex to the least complex airspace. The organizational principles underlying these strategies, rules and procedures include the following:

a) airspace management will be dynamic, flexible and based on services demanded. Airspace organizational boundaries, divisions and categories will be adapted to traffic patterns and changing situations, and will support the efficient operation of the other ATM services identified in this chapter. Flexibility within airspace organization will include regular strategic planning processes and will allow actual operations to dictate a more optimum configuration;

b) airspace will be organized to facilitate seamless handling of flights and the ability for flights to be conducted along optimum flight trajectories from gate to gate without undue restriction or delay;

c) airspace planning will be based on accommodating dynamic flight trajectories whenever practicable. Structured route systems will only be established in areas where the demand for dynamic trajectories cannot be accommodated; and

d) airspace will be organized to be easily learnable, understandable, and used by the ATM community as appropriate.

2.2.5.2 Airspace organization will be based on the principle that all airspace is managed, and all related activity within airspace will be known to the ATM system in varying degrees. “Managed” means that a strategic or tactical decision as to the level of service to be provided will have been taken by the appropriate authority.

2.2.5.3 Although there will generally be no permanent/fixed constrained airspace, certain airspace will be subjected to service limitations including access over an extended period, motivated by national interests or safety issues and appropriately considered in coordination with the ATM community.

2.2.5.4 There will always be airspace that is primarily used or organized for a specific purpose (e.g. trajectory-oriented airspace, high density airspace, special use airspace). However, aircraft not operating in that particular mode nor equipped accordingly for such airspace will be accommodated by the system where deemed safe and appropriate. Accommodation will be made without constraining the primary use of that airspace.

2.2.5.5 Priority for use of any specific airspace will not be constrained by the primary usage or equipage on a routine basis. It is recognized that airspace designation is useful but that it should not be organized in a manner that permanently precludes the possibility of mixed usage/mixed equipage operations.

2.2.6 Airspace management

2.2.6.1 Airspace management is the process by which the airspace organization options and other options in the provision of services will be selected and applied to best meet the needs of the airspace users. Competing interests for the use of airspace will make management a highly complex exercise, necessitating a process that equitably balances those interests.

2.2.6.2 The management of airspace will follow these guiding principles and strategies:

a) all airspace will be managed flexibly. Airspace boundaries will be adjusted to particular traffic flows and should not be constrained by national or facility boundaries;

b) the airspace management processes will accommodate dynamic flight trajectories and provide optimum system solutions;

c) when conditions require that different types of traffic be segregated by airspace organization, the size, shape and time regulation of that airspace will be set to minimize the impact on operations;

d) airspace use will be coordinated and monitored in order to accommodate the conflicting legitimate requirements of all users and to minimize any constraints on operations;

e) airspace reservations will be planned in advance with changes made dynamically whenever possible. The system will also accommodate unplanned requirements;

f) structured route systems will be applied only where required to enhance capacity or to avoid areas where access has been limited or where hazardous conditions exist;

g) uniform airspace organization and management principles will be applicable to all regions. Global principles will be applicable at all levels of density and will affect total traffic volume. Complex operations may limit the degree of flexibility; and

h) areas that should strive for the earliest and shortest implementation are those where the ATM community expectations are not being met.

2.3 Aerodrome operations

2.3.1 Aerodrome operations describe the aerodrome functionality within the ATM system in terms of such factors as information acquisition and delivery, facility access, demand on airspace and limits on usability. There will be a dependency on landside operations where improvements will be needed to optimise aerodrome capacity.

2.3.2 Aerodrome operations will be considered from an en-route to en-route perspective in determining its role within the ATM system.

2.3.3 The principal challenge to aerodrome operators will be to provide sufficient aerodrome capacity, while the challenge to the ATM system will be to ensure that all available capacity is fully and efficiently utilized.

2.3.4 Aerodrome operation principles include the following:

a) runway occupancy time will be reduced;

b) the ability to safely manoeuvre in all weather conditions while maintaining capacity; and

c) any activities that take place on the manoeuvring area or apron upon which aircraft (and vehicles) move, will be considered as having a direct influence on ATM.

2.3.5 Where required, runway geometry will permit runway entry and exit at any location along its length, minimizing runway occupancy time and reducing holding areas.

2.3.6 Precise surface guidance to and from a runway will be required in all conditions. The position (to an appropriate level of accuracy) and intent of all vehicles and aircraft operating on the manoeuvring and movement areas will be known and available to the appropriate ATM community members.

2.3.7 Landside activities not directly related to the ATM system will have an impact on aerodrome operations. These activities include, *inter alia*, customs, security, baggage handlers, fuel supply, etc. and will be optimised through the collaborative exchange of information.

2.3.8 Environmental issues such as noise, gaseous emissions and visual intrusions will be considered in the design, development and operation of aerodromes. Restrictions on airside operations may occur due to environmental constraints and public concern.

2.3.9 Flight parameters will be available to the ATM system, allowing for dynamic spacing and sequencing of departing aircraft thereby minimizing wake vortex constraints on runway capacity.

2.4 Demand and capacity balancing

2.4.1 The function of demand and capacity balancing will be to minimize the effects of ATM system constraints. Demand and capacity balancing will be capable of evaluating system-wide traffic flows and capacities in order to implement necessary actions in a timely manner. A collaborative process will allow for the efficient management of the air traffic flow through the use of information on system-wide air traffic flow, weather and assets.

2.4.2 Demand and capacity balancing will allow airspace users to optimise their participation in the ATM system while mitigating conflicting needs for airspace and aerodrome capacity. Collaborative usage of decision support tools will ensure the most efficient use of airspace resources; provide the greatest possible access to airspace resources; provide equitable access for all airspace users; accommodate user preferences; and, ensure that demand on an airspace resource will not exceed its capacity.

2.4.3 Demand and capacity balancing will be integrated within the ATM system. Demand and capacity balancing will be undertaken at the strategic, pre-tactical and tactical stages, defined as follows:

a) **Strategic stage.** At the strategic stage, demand and capacity balancing will respond to the fluctuations in schedules and demands, including the increasing globalization of traffic patterns, as well as the seasonal changes of weather and major weather phenomena. This stage will begin as soon as practicable. Through collaborative decision-making, assets will be optimised to maximize throughput, thus providing a basis for predictable scheduling.

b) **Pre-tactical stage.** At the pre-tactical stage, demand and capacity balancing will evaluate the current allocation of ATM service provider, airspace user and aerodrome operator assets and resources against the projected demands. Through collaborative decision-making, when possible, adjustments will be made to assets, resource allocations, projected trajectories, airspace organization and allocation of entry/exit times for aerodromes and airspace volumes to mitigate any imbalance.

c) **Tactical stage.** At the tactical stage, demand and capacity balancing will focus more closely on demand management to adjust imbalances. It will consider weather conditions, infrastructure status, resource allocations, and disruptions in schedules that would cause an imbalance to arise. Through collaborative decision making, these actions will include dynamic adjustments to the organization of airspace to balance capacity; dynamic changes to the entry/exit times for aerodromes and airspace volumes; and adjustments to the schedules by users.

2.4.4 Demand and capacity balancing principles include the following:

a) the difference between user-requested trajectories and actual trajectories will be optimised by the system to be as small as possible for individual flights;

b) recognition of deficiencies and optimization of assets will ensure maximum capacity through the balancing of operations against available assets;

c) balancing techniques will be generally based on system predictability; however, systems must be able to accommodate unplanned situations;

d) the balancing of demand and capacity will be performed from gate to gate;

e) system-wide balancing techniques will also be used to resolve local demand and capacity balancing problems;

f) strategic initiatives will require tactical flexibility to provide optimal airspace availability; and

g) demand and capacity balancing will take into account information about current and predicted airspace conditions and projected demand as well as past performance. Tools to strategically identify areas and times of higher density will also be available.

2.4.5 Advance demand and capacity balancing information will be made available to all airspace users and service providers, including aerodrome operators, to establish a common understanding of needs and capabilities. This will allow the development of collaborative strategies that will be more responsive to the situation.

2.4.6 In any ATM environment there will be intrinsic factors that impact the decision-making processes with respect to demand and capacity balancing. These include, inter alia:

a) **Limitation of real-time operational decision-making.** In trying to balance demand and capacity, decisions will be made based on available information that may be constantly changing, often as decisions are being made.

b) **Limited window of opportunity.** Decisions made in balancing demand with capacity will often be made quickly as the opportunity to achieve a solution is usually associated with a brief window of opportunity.

c) **Inaccuracy of prediction.** Decisions will be made regarding future states of the system that can only be estimated based on current data. For example, weather, which often reduces the capacity of airspace resources, cannot be accurately predicted, nor can its precise impact on airspace resources be known in advance.

d) **Stochastic nature of air traffic patterns.** The pattern of air traffic is highly complex. The effect of any one action on the overall flow of traffic cannot be modelled with certainty. Therefore, decision-makers will have to take actions, the effects of which cannot always be precisely predicted.

2.5 Traffic synchronization

2.5.1 Traffic synchronization refers to the tactical establishment and maintenance of a safe, orderly and efficient flow of air traffic. Traffic synchronization is inter-related with both conflict management and demand and capacity balancing and will be fully integrated with these, leading to a continuous and organized flow of traffic.

2.5.2 Traffic synchronization is encompassed within both the ground and the airborne part of ATM and will constitute a flexible mechanism for capacity management by allowing reductions in traffic density and adjustments of capacity to variations in demand.

2.5.3 Traffic synchronization will make use of integrated and automated assistance to surface, departure, arrival and en-route management to ensure an optimum traffic flow. The objective will be to eliminate chokepoints and ultimately to optimise traffic sequencing to achieve maximization of runway throughput.

2.5.4 Traffic synchronization, together with the other ATM components, will contribute to the efficient handling of traffic from gate to gate. There will be dynamic 4-D trajectory control and negotiated conflict-free trajectories. These techniques will reduce the need for traditional path stretching in high traffic density areas and will reduce the adverse impact this has on economy and efficiency.

2.5.5 Traffic synchronization will be applicable and tailored to all airspace and aerodromes where the optimized ordering and sequencing of traffic is critical to accommodate demand.

2.5.6 Traffic synchronization principles include the following:

a) the ability to tactically and collaboratively modify sequences to optimise aerodrome operations including gate management and/or airspace user operations;

b) evolution into 4-D control where a flight is given a time profile to follow to optimise throughput;

c) delegation of maintenance of spacing to the flight deck to increase traffic throughput while reducing ground system workload; and

d) wake vortex will continue to be a determinant of minimum spacing. Flight parameters will be available to the ATM system, allowing for dynamic spacing and sequencing of arriving and departing aircraft.

2.6 Airspace user operations

2.6.1 Airspace user operations refer to the ATM-related aspect of flight operations.

2.6.2 The ATM system will accommodate diverse types of airspace user missions. These are expected to encompass, but are not limited to, air transport, military missions, business, aerial work and recreation. These missions will have differences in planning horizons; from scheduled well in advance to just prior to flight.

2.6.3 The ATM system will accommodate diverse types of vehicle characteristics and capabilities.

2.6.4 Both manned vehicles and unmanned aerial vehicles will form part of the ATM system. The ATM system will accommodate the limited ability of some vehicles to dynamically change trajectory.

2.6.5 The evolution of ATM services will provide operational benefits and incentives commensurate with aircraft capabilities. It will have to be recognized, however, that the degree to which benefits and incentives can be realized may continue to differ with respect to the types of users. The development of ATM system and aircraft capabilities based on global standards, will ensure global interoperability of ATM systems and airspace user operations.

2.6.6 Aircraft design, including avionics, and operational characteristics have an influence on ATM performance (e.g. wake vortex, environmental considerations, aerodrome requirements, etc.). The interrelationship and interdependencies of aircraft design with ATM performance is a key consideration for aircraft and ATM system design.

2.6.7 Airspace user operations principles include the following:

a) relevant ATM data will be fused for an airspace user's general, tactical and strategic situational awareness and conflict management;

b) relevant airspace user operational information will be made available to the ATM system; and

c) individual aircraft performance, flight conditions, and available ATM resources will allow dynamically optimised 4-D trajectory mangement.

2.6.8 Mission planning

2.6.8.1 Mission planning is performed by airspace users as a collaborative exercise with airspace organization and management, aerodrome operations and demand and capacity balancing as appropriate to ensure that the ATM system will be able to accommodate their mission.

2.6.9 Operational control

2.6.9.1 Operational control is a function exercised by airspace users with respect to an individual mission and means the exercise of authority over initiating, conducting and terminating a mission.

2.6.9.2 Operational control activities are extended over the diverse types of airspace user missions. They incorporate a number of elements including management of mission, management of the individual flights, and collaboration with ATM.

2.6.10 Flight operations

2.6.10.1 Aircraft capabilities consistent with the applicable airspace management requirements will allow airspace users to fly user-preferred trajectories.

2.7 Conflict management

2.7.1 Function

2.7.1.1 The function of conflict management will be to limit, to an acceptable level, the risk of collision between aircraft and hazards.

2.7.2 Relevant terms

2.7.2.1 Conflict is any situation involving an aircraft and hazard in which the applicable separation minima may be compromised.

2.7.2.2 Conflict horizon is the extent to which hazards along the aircraft's future trajectory are considered for separation provision.

2.7.2.3 Hazards that an aircraft will be separated from are: another aircraft, terrain, weather, wake turbulence, incompatible airspace activity and when the aircraft is on the ground, surface vehicles and other obstructions on apron and manoeuvring area.

2.7.2.4 Separation minima are the minimum displacements between an aircraft and a hazard that maintain the risk of collision to an acceptable level of safety.

2.7.2.5 Separation mode is an approved set of rules, procedures and conditions of application associated with separation minima.

2.7.2.6 Separation provision is the tactical process of keeping aircraft away from hazards by at least the appropriate separation minima.

2.7.3 Conflict management layers

2.7.3.1 Conflict management is applied in three layers, comprising:

a) strategic conflict management;

b) separation provision; and

c) collision avoidance.

2.7.3.2 The conflict management process can be applied at any point along the conflict horizon, from flight formulation stage or schedule preparation well in advance of flight, to actual flight in real time.

2.7.4 Strategic conflict management

2.7.4.1 Strategic conflict management is the first layer of conflict management and is achieved through the airspace organization and management, demand and capacity balancing and traffic synchronization components.

2.7.4.2 The term “strategic” is used here to mean “in advance of tactical”. This recognizes that a continuum exists from earliest planning of the user activity through to the latest avoidance of the hazard. Strategic actions will normally occur prior to departure; however, they are not limited to pre-departure, particularly in the case of longer duration flights. Changes to the trajectory (whether on request of the user or by the service provider) will result in selection of the best means of conflict management, which may be strategic.

2.7.4.3 Strategic conflict management measures aim to reduce the need to apply the second layer — separation provision — to an appropriate level as determined by the ATM system design and operation.

2.7.5 Separation provision

2.7.5.1 Separation provision is the second layer of conflict management and is the tactical process of keeping aircraft away from hazards by at least the appropriate separation minima. Separation provision will only be used when strategic conflict management — i.e. airspace organization and management, demand and capacity balancing and traffic synchronization — cannot be used efficiently.

2.7.5.2 Separation provision is an iterative process, applied to the conflict horizon. It consists of:

a) detection of conflict, which is based on the current position of the aircraft involved and their predicted trajectories in relation to known hazards;

b) formulation of solution, including selection of the separation modes, to maintain separation of aircraft from all known hazards within the appropriate conflict horizon;

c) implementation of the solution by communicating the solution and initiating any required trajectory modification; and

d) monitoring the execution of the solution to ensure that the hazards are avoided by the appropriate separation minima.

2.7.5.3 Where a new trajectory is being considered then the new trajectory should be checked to be free from conflicts within a considered conflict horizon. In order to minimize changes to aircraft trajectories, the conflict horizon will be extended as far as procedures and information permit. It is recognized that the conflict horizon may be reduced to solve near-term conflict when required.

Separation modes

2.7.5.4 Separation mode is an approved set of rules, procedures and conditions of application associated with separation minima.

2.7.5.5 The separation mode will take in account, *inter alia*: the safety level required; the nature of the activity and hazard; the qualifications and roles of the actors; and other conditions of application, if applicable, such as weather conditions and traffic density.

Separator

2.7.5.6 The separator is the agent responsible for separation provision for a conflict, and can be either the airspace user or a separation provision service provider.

2.7.5.7 The separator must be defined (that is pre-determined) prior to the commencement of separation provision; however the role of separator may be delegated.

Pre-determined separator

2.7.5.8 Before the commencement of separation provision, it is essential that there is no ambiguity as to the agent responsible for keeping an aircraft separated from hazards. This agent will be called the pre-determined separator, as this role is determined prior to any need for separation provision. For any airspace user activity, the pre-determined separator must be defined for all hazards; however different pre-determined separators may be defined for different hazards. For example, in some cases, the airspace user may be the pre-determined separator in respect of weather and terrain, and the separation service provider will be the pre-determined separator in respect of other hazards.

2.7.5.9 The role of separator may be delegated. When delegation occurs, the term separator applies to the agent currently responsible for separating the aircraft from delegated hazards (the agent who has accepted the delegation). The term pre-determined separator refers to the agent that the responsibility will ultimately transfer back to after the condition that terminates all delegations.

2.7.5.10 The ATM system will be designed to minimize restrictions to user operations and, in particular will be designed to avoid, where possible, tactical changes to trajectories; therefore, the pre-determined separator will be the airspace user, unless safety or ATM system design requires a separation provision service.

Self separation

2.7.5.11 Self-separation is the situation where the airspace user is the separator for their activity from one or more hazards.

2.7.5.12 Full self-separation is where the airspace user is the separator for their activity in respect of all hazards. In this case, no separation provision service will be involved; however, other ATM services, including strategic conflict management services, may be used.

Distributed separation

2.7.5.13 Distributed separation is when, for an airspace user's activity, there are different separators for different hazards. This can be because different pre-determined separators have been defined or because delegation of separation has occurred.

Cooperative separation

2.7.5.14 Cooperative separation is when the role of separator is delegated. This delegation is considered temporary and the condition that terminates the delegation will be known. The delegation can be for types of hazards or from specified hazards. If the delegation is accepted, then the accepting agent is responsible for compliance with the delegation, using appropriate separation modes.

Note.— Participation in separation provision does not necessarily mean cooperative separation. Cooperative separation refers to the delegation of the role of separator, not simple compliance with instructions or suggestions.

Separation provision service

2.7.5.15 A separation provision service will be available when safety or ATM design requires.

2.7.5.16 Full separation provision service is when the service provider is the separator for an airspace user's activity from all hazards.

Separation provision intervention capability

2.7.5.17 In the development of separation modes (including determination of separators and minima), separation provision intervention capability must be considered. This capability is expected to have different values depending on whether intervention is from a separation provision service, by a user, or by an automated system. This capability will take into consideration human factors principles. Humans may rationalize complex separation minima to a particular value for application.

2.7.5.18 The separation provision intervention capability refers to the quality of human and/or system to detect and to solve a conflict, to implement and to monitor the solution. The surveillance, communication, and navigation performance, complex situation assessment and problem solving capabilities are inputs in determining the intervention capability.

2.7.6 Collision avoidance

2.7.6.1 Collision avoidance is the third layer of conflict management, and must activate when the separation mode has been compromised. Collision avoidance is not part of separation provision, and collision avoidance systems are not included in determining the calculated level of safety required for separation provision. Collision avoidance systems will, however, be considered part of the ATM safety management. The collision avoidance functions and the applicable separation mode, although independent, must be compatible.

2.8 ATM service delivery management

2.8.1 Process

2.8.1.1 The function of ATM service delivery management will manage the balance and consolidation of the decisions of the various other processes/services, as well as the time horizon at which, and the conditions under which these decisions are made. Services to be delivered by the ATM service delivery system will be established on an on-request basis subject to ATM system design. ATM system design will be determined by collaborative decision-making and system-wide safety and business cases.

2.8.1.2 When ATM services have been requested, the process will consist of building an agreement on the flight trajectory based on the user wishes and preferences, the constraints and opportunities related to the other services, and the information available on the operational situation. The agreement will then be the subject of monitoring. A significant deviation from the agreement, as it can be observed or inferred from information available, will trigger a revision to the agreement or a warning to draw attention on the need to revert to the agreement.

2.8.1.3 ATM service delivery management will manage the distribution of the responsibilities for the various services and their seamless performance, including the designation of pre-determined separator for separation provision. This function will be important to ensure that the services delivered by the ATM service delivery system will, through collaborative decision-making, balance and optimise user-requested trajectories to achieve the ATM community’s expectations.

2.8.1.4 To maintain situation awareness, ATM service delivery management will monitor a wide range of non-flight-specific infrastructure and traffic demand information.

2.8.1.5 ATM service delivery management principles include:

2.8.2 Trajectory, profile, and aircraft or flight intent

2.8.2.1 The future ATM system based on this concept, will rely on explicit and unambiguous information and on wide information exchange within the system. Key information relates to the future position of aircraft, and to the meaning and status of that information.

2.8.2.2 System-delivered trajectories will take into account aircraft performance characteristics.

2.8.2.3 The notification of intent will be a means for airspace users to specify their request for services and the nominal capabilities available during the flight.

2.8.2.4 The notification of intent will satisfy the gate-to-gate, collaborative decision-making and network management requirements.

2.8.3 Management by trajectory and notion of clearance

2.8.3.1 Management by trajectory will involve the development of an agreement that extends through all the physical phases of flight. The trajectory will never be allowed to have an open-ended vector, which means every manoeuvre will be reflected as an update to the agreement. Management by trajectory does not mean that every aspect of a flight, including arrival profile, runway, taxi path and gate needs to be predetermined and captured in detail in the agreement at the time of departure. The agreement and the management of that agreement will have the detail required by the traffic management phases that the flight is subject to at the time the initial agreement and subsequent updates are made.

2.8.3.2 Clearances will allow the incremental delivery of the trajectory by the ATM system based on the assignment of traffic. Therefore, although the flight deck and the ATM system will have entered into a “gate-to-gate” agreement, that agreement will be actively affirmed by the delivery of each portion of the trajectory as a clearance.

2.9 Information services

2.9.1 The function of information services deals with the exchange and management of information used by the different processes and services. It will ensure the cohesion and linkages between the seven concept components described above.

2.9.2 Information management

2.9.2.1 Information management provides accredited quality-assured and timely information used to support ATM operations. Information management will also monitor and control the quality of the shared information and provide information-sharing mechanisms that support the ATM community.

2.9.2.2 Information management will assemble the best possible integrated picture of the historical, real-time and planned or foreseen future state of the ATM situation. Information management will provide the basis for improved decision-making by all ATM community members. Key to the concept will be the management of an information-rich environment.

2.9.2.3 Information management will contribute to the expectations of the ATM community through all operational services. Its more direct contribution to improvement in the ATM system will be in the quality of the information that will, in turn, provide significant additional benefits. In particular, the wide availability of high quality, relevant aeronautical data presented to all airspace users in a usable format will contribute to increased aviation safety.

2.9.2.4 The ATM community will depend on information management, shared on a system-wide basis, to make informed collaborative decisions for best business and operational outcomes. Within the ATM system based on this operational concept, it will be the information itself that will be of significance and not the technology that supports it.

2.9.2.5 For the ATM system to operate at its full potential, pertinent information will be available when and where required.

2.9.2.6 ATM data has temporality and will change over time but to varying degrees in terms of frequency or magnitude, varying from almost static to very dynamic. Information management will recognize and accommodate this temporality of data. This will impact the organization and issuance of data.

2.9.2.7 Information may be personalized and filtered, and accessed as needed. The initial quality of the information provided will be the responsibility of the originator; subsequent handling will not compromise its quality.

2.9.2.8 The information management function will allow all participants to adjust information sharing to mitigate any proprietary concerns. Sensitivities with regard to some data will continue to exist and will be managed within the information management function. Once an ATM community member agrees to release information, the data will be available to the extent required and will be made accessible to specified parties.

2.9.2.9 Information management will achieve a seamless transfer of relevant information between parties in a flexible, adaptable and scalable information environment.

2.9.2.10 Information management will use globally harmonized information attributes.

2.9.3 Aeronautical information

2.9.3.1 The scope of information management includes all types of information, in particular the aeronautical information. Since the architecture and organization of information services are implementation issues, this operational concept does not describe the traditional notion of aeronautical information services (AIS) as they are in 2000. Nevertheless, in addition to the intrinsic characteristics of information management, servicing information will incorporate the following basic concepts.

Temporality and issuance

2.9.3.2 Temporality of the information depends on its nature. Some data can be prepared in advance and are valid for a rather long period; other data change in real-time and are obsolete immediately. As a principle, any valid and relevant information will be made available as soon as it becomes available.

2.9.3.3 In order to satisfy the requirements of all information users and to avoid waste of resources and the risk of information overload, information management will use a variety of information issuance concepts in relation to the application using it and the media used to carry it. Typically, the information relevant to a flight will be tailored and filtered, and accessible dynamically as the flight is planned and then progresses. Intelligent information management will be used to realise virtually “unlimited” access to information with “limited” bandwidth, and optimise the transfers of information.

Media

2.9.3.4 The reference medium for aeronautical data will be a fully electronic and networked environment, with printouts used only as needed for reference, temporary memorization and visualization support to human operators.

2.9.3.5 Information will use a variety of channels on the ground (and space-based segments). The best information routing will be selected for use on the basis of quality of service and economic criteria, possibly in real-time.

2.9.4 Meteorological information

2.9.4.1 The provision of meteorological information will be an integrated function of the ATM system. The information will be tailored to meet the ATM requirements in terms of content, format and timeliness.

2.9.4.2 The main benefits of the meteorological information for the ATM system will be related to the following:

a) improved accuracy and timeliness of meteorological information will be used to optimize the flight trajectory planning and prediction, thus improving safety and efficiency of the ATM system;

b) increased availability of shared meteorological information on board the aircraft will allow the preferred trajectory to be refined in real-time;

c) better identification, prediction and presentation of adverse weather will allow the management of its effects more efficiently, thereby improving safety and flexibility, for example, by providing accurate and timely information on the need for diversion or rerouting;

d) improved aerodrome reports and forecasts will facilitate the optimum use of available aerodrome capacity;

e) increased availability of meteorological information (air-reports) from on board meteorological sensors will contribute to improve forecast meteorological information and the display of real-time information; and

f) meteorological information will contribute to minimizing the environmental impact of air traffic.

2.9.4.3 Performance management will be an important part of the quality assurance of meteorological information.

2.9.5 Other essential services

2.9.5.1 There are other essential activities that the ATM system will provide information to, or may receive information from. These include the following:

a) *Air defence systems and military control systems* will need timely and accurate information on flights and ATM system intents. They will be involved in airspace reservations and notification of air activities and in enforcing measures related to security.

b) *Search and rescue organizations* will need timely and accurate search and rescue information on aircraft in distress and accidents as such information plays an important role in the quality of the search function.

c) *Aviation accident/incident investigation authorities* will need to exploit recordings of flight trajectory and ATM actions.

d) *Law enforcement (including customs and police authorities)* will need flight identification and trajectory data, as well as information about traffic at aerodromes.

e) *Regulatory authorities* will need to implement the regulatory framework within the legal powers given to them and to monitor the safety status of the ATM system.

2.9.5.2 These entities have a defined relationship with the ATM system and all will impose requirements on the system.

APPENDIX A

THE ATM COMMUNITY

The ATM community is presented in alphabetical order rather than in any order of importance or priority.

Aerodrome community

The aerodrome community includes aerodromes, aerodrome authorities, and other parties involved in the provision and operation of physical infrastructure needed to support the take-off, landing and ground handling of aircraft. The numerous aerodrome activities not directly related to aircraft flight operations (e.g. passenger processing, baggage handling, catering services, customs and immigration) were determined to be outside the scope of the ATMCP and were not considered in developing the ATM Operational Concept.

Airspace providers

The term *airspace provider* generally refers to the Contracting States in their capacity of airspace owners with the legal authority to allow or deny access to their sovereign airspace. It may also apply to organizations of States that have been assigned responsibility for establishing the rules and guidelines for the use of airspace. The airspace provider is responsible for addressing and resolving issues such as airspace sovereignty, diplomatic clearance, and national security (e.g. air defence) requirements. The airspace provider has an important role in achieving the benefits of collaborative ATM by ensuring that the airspace is organized and managed for both the safety and efficiency of service.

Airspace users

The term *airspace users* mainly refers to the organizations operating aircraft and their pilots. In developing the ATM operational concept, three classifications of airspace users are considered.

a) ICAO compliant manned flight operations (the largest segment by far);

b) ICAO non-compliant manned flight operations; and

c) flight operations of unmanned aerial vehicles (UAVs).

ICAO compliant manned flight operations are those conducted in accordance with ICAO provisions (e.g. SARPs, PANS-ATM). The ICAO-compliant airspace users include:

a) all civil aircraft operators (i.e. those engaged in commercial air transport (passenger, mail and cargo services), aerial work, air taxi operators, business aviation, private air transport, sporting and recreational aviation, etc.; and

b) the portion of States' users operating State aircraft using civil air traffic rules.

ICAO non-compliant manned flight operations are those conducted by State aircraft which cannot comply for operational or technical reasons.

Flight operations of unmanned aerial vehicles (UAVs) — a growing segment of airspace users — include both defence UAVs and civil applications of UAV technology. In certain situations, UAV technology is seen as a more cost-effective solution than the use of conventional aeroplanes or helicopters.

In some circumstances using UAVs is simply safer and it may also be the only possible way to get a particular job done. However, the emerging requirement for non-segregated operations of civil UAVs is totally new and no regulatory framework for such operations currently exists.

ATM service providers

The ATM service providers comprise all those organizations and personnel (e.g. controllers, engineers, technicians) that are engaged in the provision of ATM services to airspace users. ATM service provider responsibilities include CNS/ATM facility planning, investment, and implementation; procedure development; training; and ongoing system operation and maintenance of seamless CNS/ATM services. ATM service provider organizations include:

a) State agencies;

b) State-owned self-financing corporations;

c) privatised ATM service providers;

d) regional ATM service providers; and

e) independent private sector ATM service providers of ground and space-based CNS/ATM services.

ATM support industry

The ATM support industry comprises all those organizations that offer systems and services used by ATM service providers to provide CNS/ATM facilities and seamless services that achieve the ATM operational concept vision. In particular, the support industry includes:

a) information service providers;

b) equipment manufacturers;

c) research and development (R&D) organizations; and

d) aviation standards development organizations.

Information service providers are government or private sector organizations that are not ATM service providers per se but who are engaged in the collection and dissemination of air navigation related information of an operational nature. This includes environmental information (e.g. maps, navigation databases), ground, airborne and space-based weather observation and aviation weather forecasting.

Equipment manufacturers are typically private sector corporations that are engaged in the development, production, implementation, testing, and support of equipment used by ATM service providers, airspace users, aerodromes, and meteorological service providers, among others. This segment includes: airframe manufacturers, avionics manufacturers, CNS/ATM equipment manufacturers (e.g. computers and telecommunications equipment), engine manufacturers, satellite manufacturers and operators, systems integrators, and industry associations.

R&D organizations are engaged in the planning, funding and execution of R&D programmes aimed at progressing the state of the art in the field of aviation in general, and ATM in particular. R&D topics of interest directly related to the ATMCP Operational Concept include:

a) data link communications;

b) satellite navigation and augmentation;

c) enhanced surveillance using aircraft provided information;

d) controller decision support tools;

e) cockpit and controller shared situational awareness; and

f) human factors evaluations of new concepts of use for CNS/ATM technologies.

Aviation standards development organizations allow the ATM community to cooperate and develop consensus on the many technical and operational details needed to implement the global, interoperable ATM system defined by ICAO.

International Civil Aviation Organization (ICAO)

ICAO is the only international organization in a position to effectively coordinate global ATM implementation activities leading to the realization of a seamless, global ATM system. The ATM Operational Concept vision has therefore been stated as follows:

> *To achieve an interoperable global ATM system for all users during all phases of flight that meets agreed to levels of safety; provides for optimum economic operations; is environmentally sustainable, and meets national security requirements.*

The aims and objectives of ICAO in accordance with Article 44 of the Convention on International Aviation are to develop the principles and techniques of international air navigation and foster the planning and development of international air transport. ICAO ensures the safe and orderly growth of international civil aviation throughout the world. Recognizing the limitations of the present terrestrial-based system, ICAO, working with its Contracting States, international organizations and other community members developed the communications, navigation and surveillance/air traffic management (CNS/ATM) systems concept to serve the interests and the objectives of civil aviation throughout the world.

In accordance with its obligations under the Convention, ICAO continues to carry out its responsibility concerning the adoption and amendment of relevant international SARPs and procedures. These SARPs and procedures are continually being reviewed and updated while new ones are being developed to accommodate CNS/ATM systems requirements. This continuing practice supports the principle of universal accessibility without discrimination by ensuring the highest possible degree of uniformity in all matters concerning safety, regularity and efficiency of air navigation.

Finally, ICAO has developed this operational concept document, working through the CNS/ATM community, in an attempt to establish a vision, with clearly stated objectives and benefits of a seamless and global ATM system.

Regulatory authorities

Regulatory authorities are responsible for certain aspects of the overall performance of the aviation industry — most significantly, aviation safety — and other areas including environmental impact, and international trade. Regulatory authorities plan the desired performance through safety standards; pilot, controller, and system certification; and environmental regulations, to mention just a few. They then monitor the aviation system results and investigate accidents, incidents and other unexpected occurrences and make recommendations and implement new regulations and standards to improve aviation system performance.

The aviation regulatory authorities include: aviation safety regulators, certification authorities (e.g. aircraft, systems, pilots, controllers, maintenance technicians), standardization organizations, environmental regulators, and independent accident/incident investigation authorities, among others.

States

Global implementation of a seamless ATM system through the provision of CNS/ATM facilities and seamless services 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. Furthermore, in pursuing the ATM operational concept vision, States should make optimum use of existing organizational structures, wherever possible, and ATM services should be delivered in accordance with existing institutional arrangements and regulations. Where modification becomes necessary, this will be accomplished through the already established international mechanisms.

Implementation should be sufficiently flexible to accommodate existing and future services in an evolutionary manner. It is recognized that a globally coordinated implementation, with full involvement of ICAO, the States, and other community members — including the rationalization, integration and harmonization of CNS/ATM facilities, where appropriate — is the key to the realization of full benefits from collaborative ATM.

For the five decades after the founding of ICAO in 1944, the Contracting States were generally responsible for acting as the regulatory authority, airspace provider, and ATM service provider for aviation activities within their sovereign airspace and in the flight information regions for which they are responsible. Within the past ten to fifteen years many Contracting States have established innovative institutional arrangements (e.g. multi-national regulatory organizations, harmonized airspace planning and organization across several States, and autonomous ATM service providers) to meet their aviation responsibilities and needs. Therefore, while the Contracting States remain members of the ATM community per se, the role of some members of the ATM community who complete activities or provide services that were traditionally the responsibility of Contracting States have evolved and are listed below:

a) regulatory authority;

b) airspace provider; and

c) ATM service provider.

APPENDIX B

EXPLANATION OF TERMS

The explanations of terms contained herein are used in association with those terms in the context of this ATM operational concept. Except where indicated, they have no official status within ICAO. Where a term is used differently from an ICAO formally-recognized definition, this is noted.

Airside. The contiguous area within and extending to the aerodrome perimeter prepared, intended, and set aside for the movement, servicing, and loading of aircraft or where aircraft can otherwise be situated.

Air traffic management (ATM).[1] The dynamic, integrated management of air traffic and airspace — safely, economically, and efficiently — through the provision of facilities and seamless services in collaboration with all parties.

Air traffic management system. A system that provides ATM through the collaborative integration of humans, information, technology, facilities and services, supported by air, ground and/or space-based communications, navigation and surveillance.

Aircraft intent. Information on the planned future aircraft behaviour that can be obtained from the aircraft systems (avionics). It is associated with the commanded trajectory, and will enhance airborne functions. The aircraft intent data either correspond to aircraft trajectory data that directly relate to the future aircraft trajectory as programmed inside the avionics; or aircraft control parameters, as managed by the automatic flight control system. These aircraft control parameters could be either entered by the flight crew, or automatically derived by the flight management system.

Airspace management. The process by which the airspace options are selected and applied to meet the needs of the ATM community.

ATM operational concept. This ATM operational concept is a high-level description of ATM services necessary to accommodate traffic at a given time horizon; a description of the anticipated level of performance required from, and the interaction between, the ATM services, as well as the objects they affect; and a description of the information to be provided to agents in the ATM system and how that information is used for operational purposes. The operational concept is neither a description of the air navigation infrastructure, nor a technical system description nor a detailed description of how a particular functionality or technology could be used.

ATM community. The aggregate of organizations, agencies or entities that may participate, collaborate, and cooperate in the planning, development, use, regulation, operation and maintenance of the ATM system. (Appendix A refers)

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[1] The ICAO definition contained in the *Procedures for Air Navigation Services — Air Traffic Management* (PANS-ATM, Doc 4444) is different from the explanation given herein.

Availability. The ability of a system to perform its required function at the initiation of the intended operation. It is quantified as the proportion of the time the system is available to the time the system is planned to be available.

Benefit. Reduced cost to the user (to the ATM community as a whole), in the form of savings in time and/or fuel or increased revenue, and/or an improvement to safety.

Capability. The ability to provide a service or perform a function that, either on its own or with other services or functions, can deliver a definable level of performance provided by a system. This level of performance is measurable within a framework of performance indicators and safety requirements.

Capacity. The maximum number of aircraft that can be accommodated in a given time period by the system or one of its components (throughput).

Conflict. Any situation involving an aircraft and hazard in which the applicable separation minima may be compromised.

Conflict horizon. The extent to which hazards along the aircraft's future trajectory are considered for separation provision.

Constraint. Any limitation to the implementation of an "operational improvement".

Continuity. The probability of a system to perform its required function without unscheduled interruptions during the intended period of operations.

Cooperative separation. Delegation of the role of "separator". The delegation can be for a particular type of hazard or from nominated hazards. If the delegation is accepted, then the accepting party is responsible for compliance with the delegation, using appropriate separation modes.

Delay. The difference between actual block time and ideal block time.

Demand. The number of aircraft requesting to use the system in a given time period.

Efficiency. Ratio of the cost of ideal flight to the cost of procedurally constrained flight.

Enablers. Initiatives, such as (new) technologies, systems, operational procedures, operational or socio-economic developments, etc. which facilitate the implementation of operational improvements or of other enablers.

Equity. The first aircraft ready to use the ATM resources will receive priority, except where significant overall safety or system operational efficiency would accrue or national interests dictate providing priority on a different basis. Equity is ensured for all airspace users that have access to a given airspace or service by the global ATM system.

Flight deck. Term encompassing flight crew and/or aircraft systems.

Flight intent. The future aircraft trajectory expressed as a 4-D profile until destination, taking account of aircraft performance, weather and terrain, ATM services' constraints, calculated and "owned" by the aircraft FMS, agreed by the pilot.

Gate-to-gate. Where the air traffic operations of the members of the ATM community are such that the successive planning and operational phases of their processes are managed and can be achieved in a seamless and coherent way.

Hazards. Those things [objects, elements] that an aircraft can be separated from. These are: another aircraft, terrain, weather, wake turbulence, incompatible airspace activity and, when the aircraft is on the ground, surface vehicles and other obstructions on apron and manoeuvring area. For any *hazard* (i.e. any conditions, event or circumstances which could induce an accident) a *risk* can be identified as the combination of the overall probability or frequency of occurrence of a harmful effect induced by the hazard and the severity of that effect. (*Accident* and *Incident* are defined in Annex 13).

Homogeneous ATM area[2]. An airspace with a common air traffic management interest based on similar characteristics of traffic density, complexity, air navigation system infrastructure requirements, or other specified considerations, wherein a common detailed plan will foster the implementation of interoperable CNS/ATM systems.

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

Landside. That portion of the aerodrome that is not considered airside. It consists primarily of passenger and cargo terminals, including appurtenances that may extend onto the airside, and those other facilities not located within the area defined by the airside.

Link. A direct connection between an operational improvement and an enabler, between operational improvements, between enablers or between lines of action. In "road-mapping" a link defines a pre-requisite or an enabler to an operational improvement, another enabler or a line of action.

Major traffic flow[2]. A concentration of significant volumes of air traffic on the same or proximate flight trajectories.

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

Operational concept. For the purposes of this document, an operational concept is defined as:

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

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

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[2] As used in the *Global Air Navigation Plan for CNS/ATM Systems* (Doc 9750).

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

The global ATM operational concept differs from “architecture” and “concept of use”. “Architecture” includes the infrastructure and a technical system description that includes specific technologies and the functions of personnel. The operational concept describes how the air traffic management system will operate and identifies the services that will be required. Identification of what specific technologies are implemented to deliver these services is defined by an “architecture” to be developed by planning and implementation regional groups (PIRGs) and States. Thus, an operational concept drives the architecture. An ATM “concept of use” is a more detailed description of how a particular functionality or technology could be used. An operational concept portrays an ideal state in the future, to be reached progressively through a number of discrete change steps from the current situation. For the global ATM operational concept, the year 2025 was selected as a point in which the majority of expectations described could be realized. Descriptions of intermediate stages were done through scenarios, combining elements of the current global situations and target concepts.

Note.— The operational concept is neither a description of the air navigation infrastructure, nor a technical system description nor a detailed description of how a particular functionality or technology could be used.

Operational concept vision. To achieve an interoperable global ATM system for all users during all phases of flight that meets agreed to levels of safety; provides for optimum economic operations; is environmentally sustainable, and meets national security requirements.

Operational control.[3] Used generically with respect to a flight means the exercise of authority over initiating, conducting and terminating a mission. It will use sophisticated flight planning, flight following, and automation tools.

Operational requirement (OR). A statement of the operational attributes of a system needed for the effective and/or efficient provision of air traffic services to users.

Option. Where an operational concept (or a technical concept) can be realized through various solutions, each of these solutions is seen as an option. Selecting/retaining an option requires investigated cost-benefit and other analyses. In some cases, only one option can be retained. In other cases, several options can be left to the choice of implementers.

Predictability. Is a measure of delay variance against a performance dependability target. As the variance of expected delay increases, it becomes a very serious concern for airlines when developing and operating their schedules. Conceptually, predictability metrics should be a comparison of the actual flight time to the scheduled flight time, since the scheduled time includes the amount of expected delay at a targeted dependability performance.

[3] The ICAO definition contained in the *Procedures for Air Navigation Services — Air Traffic Management* (PANS-ATM, Doc 4444) is different from the explanation given herein.

Required ATM performance (RASP). RASP is the set of criteria, expressed in the form of performance parameters, and values of these parameters, that the ATM system needs to meet with a given probability, in order to support the approved quality of service specified for a particular environment.

Note 1.— RASP does not mean that the system performance can be expressed by a single figure, or that performance figures have to be unique globally. Lower performance bounds for the ATM system will be defined at the global level. RASP refers to a requirement; however, initiative and choice will be left to implementers. Planning activities will respond to the difference between the current performance and the desired future targets. "Target" is understood to be the minimum that is required at a given point in time or at a given period and may also address the present.

Note 2.— Probability refers to the fact that whatever the performance parameter that must be met, it will always relate to certain traffic conditions, or to infrequent possible events, the realization, or absence of realization, of which does not constitute proof of meeting or failing the requirement.

Required total system performance (RTSP). RTSP is the aggregate of criteria, expressed in the form of performance parameters (operational and technical), that the ATM system needs to meet in order to deliver the approved quality of service and RASP specified for a particular environment.

Note 1.— The term RTSP is retained for the internal performance with "total" to contrast with elements of the system addressed by specific required enabler performance parameters relating to their outputs (e.g. required communications performance for the communication systems).

Note 2.— "Required" implies something that is mandated, or must be achieved, presumably to give some degree of assurance that something has or will be done. It gives no guidance as to the scope of application — only the sense of importance or urgency. In context, it may also imply a minimum level of action or service.

Risk management. The systematic application of management policies, procedures and practices to the tasks of establishing the context of, identifying, analysing, evaluating and treating risks, monitoring the implementation of treatments and communicating on risk.

Routing area.[4] A defined area encompassing one or more major traffic flows for the purpose of developing a detailed plan for the implementation of interoperable CNS/ATM systems.

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

Safety case. Both the argument and the document that contend the level of safety attained will satisfy the safety requirements. It intelligently and coherently argues the degree of safety achieved at any point of a system's life cycle by making rational and coherent reference to the documented results of the system safety approach defined above.

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[4] As used in the *Global Air Navigation Plan for CNS/ATM Systems* (Doc 9750).

Separation minima. The minimum displacements between an aircraft and a hazard that maintain the risk of collision to an acceptable level of safety.

Separation mode. An approved set of rules, procedures and conditions of application associated with separation minima.

Separation provision. The tactical process of keeping aircraft away from hazards by at least the appropriate separation minima.

Separation provision intervention capability. The quality of human and/or system to detect and to solve a conflict, to implement and to monitor the solution. The communication, navigation, surveillance performance, complex situation assessment and problem solving capability are inputs in determining the intervention capability.

Separator. Agent responsible for separation provision for a conflict, being either the airspace user or a separation provision service provider.

Note.— The role of the separator may be delegated; however, a pre-determined separator must be defined prior to the commencement of separation provision.

Spacing. Any application of a distance or time between an aircraft and a hazard at or above separation minima in order to maintain an orderly flow of traffic.

System safety approach. A systematic and explicit approach defining all activities and resources (people, organizations, policies, procedures, time spans, milestones, etc.) devoted to the management of safety. This approach starts before the fact, is documented, planned and explicitly supported by documented organizational policies and procedures endorsed by the highest executive levels. The system safety approach uses systems theory, systems engineering and management tools to manage risk formally, in an integrated manner across all organizational levels, across all disciplines and all system life cycle phases.

State aircraft. Aircraft used in military, customs and police services.

Strategic action. A "strategic action" describes "actions", i.e. initiatives of a general nature, which shall be launched in order to support one or several strategic objectives.

Traffic synchronization. Traffic synchronization concerns the management of the flow of traffic through merging and crossing points such as traffic around major airports or airways crossings. It currently includes management and provision of queues both on ground and in the air. The traffic synchronization, as a function, is closely related to both demand/capacity balancing and separation provision and may in the future be indistinguishable from these. It is also clear that the traffic synchronisation also concerns the airport "service" part of the concept.

Trajectory, or profile. This is the description of movement of an aircraft, both in the air and on the ground, including position, time, and at least via calculation, speed and acceleration.

Unmanned aerial vehicle (UAV). An unmanned aerial vehicle is a pilotless aircraft in the sense of Article 8 of the ICAO Convention which is flown without a pilot-in-command on board and is either remotely and fully controlled from another place (ground, another aircraft, space) or programmed and fully autonomous.

APPENDIX C

LIMITATIONS

1. EXISTING LIMITATIONS TO THE PROVISION OF AIR TRAFFIC SERVICES IN 2000

1.1 The ATM system has limitations that may occur at different times and places. These limitations include but are not restricted to:

a) disparate services and procedures resulting from differing systems and limited system and decision support tools;

b) a reliance on increasingly congested voice radio communications for air-ground exchanges;

c) rigid airspace divisions and route structures which do not allow the totality of ATM resources to be used to best effect;

d) limited collaborative planning between ATM, aerodrome operating authorities and aircraft operators;

e) less than optimum use of scarce resources such as airspace and aerodrome airside capacity;

f) limited facilities for real-time information exchange between ATM, aerodromes and aircraft operators, resulting in less than optimal responses to real-time events and changes in the users' operational requirements;

g) the limited ability to maximize benefits for aircraft with advanced avionics; and

h) the long lead-times involved in developing and deploying improved systems in aircraft fleets or in the ground infrastructure.

1.2 The limitations of the current ATM system results in inefficient aircraft operations. These inefficiencies include but are not limited to the:

a) requirement to fly circuitous departure and arrival procedures;

b) exclusion of civil air traffic from airspace reserved for defence purposes;

c) indirect fixed routes between destinations;

d) excessive system related ground and en-route delays;

e) operation of aircraft at inefficient altitudes, speeds, and in unfavourable winds; and

f) insufficient flexibility to permit optimum management of weather-related disruptions to airline operations.

APPENDIX D

EXPECTATIONS

Key to the operational concept is a clear statement of the expectations of the ATM community. The expectations for the global ATM system have been discussed among the ATM community in general terms for many years. These expectations stem from efforts to document ATM "user requirements." The expectations hereafter are interrelated and cannot be considered in isolation. Furthermore, while safety is the highest priority, the expectations are shown in alphabetical order as they would appear in English.

Access and equity

A global ATM system should provide an operating environment that ensures that all airspace users have the right of access to ATM resources needed to meet their specific operational requirements; and ensures that the shared use of the airspace for different airspace users can be achieved safely. The global ATM system should ensure equity for all airspace users that have access to a given airspace or service. Generally, the first aircraft ready to use the ATM resources will receive priority, except where significant overall safety or system operational efficiency would accrue or national defence considerations or interests dictate by providing priority on a different basis.

Capacity

The global ATM system should exploit the inherent capacity to meet airspace user demand at peak times and locations while minimizing restrictions on traffic flow. To respond to future growth, capacity must increase, along with corresponding increases in efficiency, flexibility, and predictability while ensuring that there are no adverse impacts to safety giving due consideration to the environment. The ATM system must be resilient to service disruption, and the resulting temporary loss of capacity.

Cost effectiveness

The ATM system should be cost-effective, while balancing the varied interests of the ATM community. The cost of service to airspace users should always be considered when evaluating any proposal to improve ATM service quality or performance. ICAO guidelines regarding user charge policies and principles should be followed.

Efficiency

Efficiency addresses the operational and economic cost-effectiveness of gate-to-gate flight operations from a single-flight perspective. Airspace users want to depart and arrive at the times they select and fly the trajectory they determine to be optimum in all phases of flight.

Environment

The ATM system should contribute to the protection of the environment by considering noise, gaseous emissions, and other environmental issues in the implementation and operation of the global ATM system.

Flexibility

Flexibility addresses the ability of all airspace users to modify flight trajectories dynamically and adjust departure and arrival times thereby permitting them to exploit operational opportunities as they occur.

Global interoperability

The ATM system should be based on global standards and uniform principles to ensure the technical and operational interoperability of ATM systems and facilitate homogeneous and non-discriminatory global and regional traffic flows

Participation by the ATM community

The ATM community should have a continuous involvement in the planning, implementation, and operation of the system to ensure that the evolution of the global ATM system meets the expectations of the community. The ATM community is more fully defined in Appendix A.

Predictability

Predictability refers to the ability of the airspace users and ATM service providers to provide consistent and dependable levels of performance. Predictability is essential to airspace users as they develop and operate their schedules.

Safety

Safety is the highest priority in aviation, and ATM plays an important part in ensuring overall aviation safety. Uniform safety standards and risk and safety management practices should be applied systematically to the ATM system. In implementing elements of the global aviation system, safety needs to be assessed against appropriate criteria, and in accordance with appropriate and globally standardized safety management processes and practices.

Security

Security refers to the protection against threats which stem from intentional (e.g. terrorism) or unintentional (e.g. human error, natural disaster) acts affecting aircraft, people or installations on the ground. Adequate security is a major expectation of the ATM community and of citizens. The ATM system should therefore contribute to security, and the ATM system, as well as ATM related information, should be protected against security threats. Security risk management should balance the needs of the members of the ATM community who require access to the system, with the need to protect the ATM system. In the event of threats to aircraft or threats using aircraft, ATM shall provide responsible authorities with appropriate assistance and information.

APPENDIX E

EXPECTED BENEFITS

1. The operational concept presupposes that the ATM community will work together to continually improve ATM performance, especially in relation to safety and in achieving the expectations of the ATM community.

2. Improved safety management processes will ensure that safety performance remains the highest priority. Business cases will ensure efficient and cost-effective ATM developments and operations. Collaborative decision-making and system-wide ATM information will enable airspace user participation in balancing demands on the ATM system, thereby providing flexibility and predictability.

3. Specifically, these expected benefits include:

a) all airspace will be available as a useable resource resulting in improved access; increased opportunity for user preferred trajectories and, through community cooperation, increased capacity;

b) improved surface management of the aerodrome will provide predictable departure and gate-arrival times, thereby improving overall ATM system predictability and subsequent capacity. In particular, improved runway design together with improved operational procedures will increase capacity;

c) improved information exchange and cooperation within the ATM community will maximize system capacity;

d) improved all weather operations will maintain maximum capacity;

e) the use of simulation, modelling and options evaluation tools will allow various management strategies to be considered and will provide flexibility in managing the overall ATM system while accommodating airspace user preferences;

f) improved information on demand and system capabilities will prevent system overloads ensuring manageable workloads;

g) management by trajectory and the exchange of information between airspace users and the ATM system will improve conflict management and facilitate user-preferred trajectories;

h) using an extended conflict horizon and expanding the definition of hazards will enable more stable user trajectories;

i) new separation modes will improve ATM capacity;

j) the provision of accredited quality assured and timely information will allow an informed decision-making process; and

k) the ATM community will contribute to the protection of the environment by taking into consideration the consequences of airspace activities.

APPENDIX F

ATM SYSTEM PERFORMANCE

1. GENERAL

1.1 A key tenet of the operational concept is performance orientation. Appendix D set the *expectations* of the users of ATM services. Chapter 2 defined the components that would be required to satisfy these expectations. This appendix comprises two main parts:

a) it gives a special emphasis to safety and safety management, which are the primary concern from concept inception and early design phases through to operations; and

b) it makes a first attempt to link the performance of the components to the *expectations* (including safety) through the concept of required total system performance (RTSP). However, it must be realized that the concept of RTSP is still in its infancy and requires much more work before reaching the level of maturity suitable to determine its viability.

1.2 The ATM system performance requirements should always be based on the key understanding that the ATM system is the collective integration of services, humans, information, and technology.

2. MANAGEMENT OF SAFETY

2.1 Introduction

2.1.1 Safety will remain the highest priority in aviation and the safety of air traffic will continue to be the most important consideration in all phases of the life cycle of the ATM system, from concept, through to design, development, operation and maintenance.

2.1.2 The system safety approach outlined below is holistic, applying across the spectrum of the ATM system, where the system will be considered to include people, procedures and technologies performing specific tasks in a given environment.

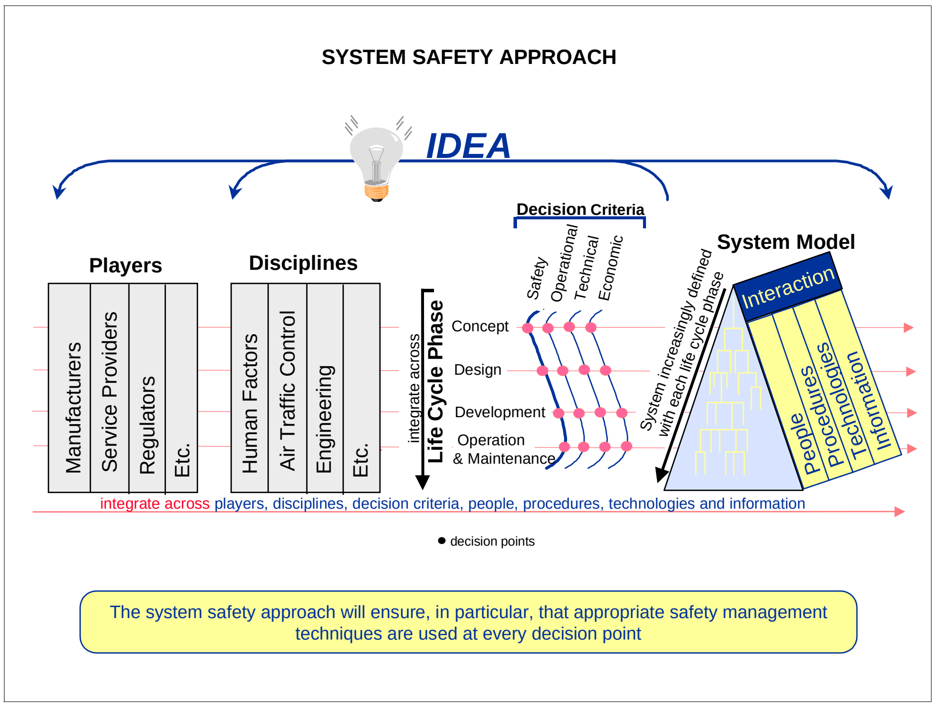
2.1.3 The purpose of this section is not to define detailed ICAO requirements for safety management systems. It is to provide the minimum description required to ensure that the holistic approach will be an integral part of the concept and of the ensuing life cycle activities. It will be subsequently refined as normative documents are produced. The acceptance of the ATM operational concept will be directly related to the evidence that can be provided on the ability for ATM to operate safely within the context of the operational concept.

2.1.4 The terms in this section may differ from other references. It is emphasized that the characteristics listed below are essential to the concept and that only a sufficient application of these can ensure safety requirements are actually met.

2.2 System safety approach

2.2.1 Maximum effectiveness and efficiency of actions can be obtained by activities undertaken in the early phases of any system's life cycle since correcting problems during requirements definition and design is generally the most effective. The following diagram describes this process for the ATM system as a whole. It describes how, starting from the conceptual level and even during operation, different players and disciplines make decisions against different criteria — including safety. These decisions will progressively define the ATM system (i.e. the way in which it is organized and in which people, procedures, technologies and information interact to perform a task).

Replace diagram from Version SL 02/56 with the following diagram:



2.2.2 This approach stems from the following reasons that ATM shares with many other activities:

a) safety will not be the result of individual system components, but rather of the working together of those components as an integrated whole;

b) a number of important past accidents and incidents across several industries demonstrate that organizations as a whole will need to adopt this systematic and traceable way of conducting safety business;

c) as accident rates diminish, the search for systemic causes will be increasingly difficult, and a common and systematic method will be necessary to build a robust framework for analysis;

d) as the pace and novelty of developments increase it will be neither sufficient nor possible to rely solely on the application of codes built on past knowledge and experience; and

e) current regulatory trends will recommend strongly the application of system safety generally, including in the ATM domain. This is because it will be a cost-effective way to maintain effectual safety regulatory oversight, while facilitating the best exploitation of innovative developments.

2.2.3 This approach implies, inter alia, the following:

a) all safety practices and processes will be explicit, and will comply with the safety requirements and standards of ICAO, State regulatory authorities and other appropriate parties;

b) each element of the ATM system, wherever implemented (aircraft, ground, space, etc.) will be subject to specific safety analysis, as an individual element, and as a component of the larger integrated system. The implementation of any element of the system will be subject to appropriate safety assurance processes;

c) where a change to a *system* implies a departure from *"currently approved operational boundaries,"* it will not be possible to determine *a priori*, without analysis, whether it will impact safety or not. Therefore, for any change, a clearly defined and explicit change management process will be used, supported by a safety case or equivalent, including the analysis of all the necessary routine and foreseeable emergency configurations;

d) clear accountabilities for all aspects of safety must be defined, and the roles and responsibilities for the management and integration of system elements must be explicitly stated. This includes clear definition of roles and responsibilities in the application of the elements of the ATM system such as allocation of separation responsibility, flow management, pilot responsibilities in various airspace, controller coordination responsibilities, system expectations, failure mode management and so on;

e) where target levels of safety have been defined, they will form the basis for assessment of the risk tolerability within a system, or component of the system. Where target levels of safety have not been defined, contemporary safety principles or comparative studies may be used, but will ensure global consistency;

f) the system safety approach will be applied across the entire ATM system. It will focus particularly on ATM processes in relation to human factors and human machine interfaces; and

g) assessment and reviews will occur during the full life cycle, including during the planning and implementation phases.

2.3 Levels of safety

2.3.1 The *acceptable or tolerable* level of safety will be determined from the perception of safety needs by the society and the international community. Acceptable safety will be related to the trust required from the ATM system.

2.3.2 The *target* level of safety will be the minimum level of safety to be achieved in any case. Possibly enforced by regulation, it will be equal to or better than the acceptable level of safety. The target level of safety will be based on risk assessment and acceptance criteria.

2.3.3 The *observed* level of safety is that which will be measurable. The observed level could produce results in a defined range without compromising acceptable and target levels of safety.

2.3.4 These levels of safety could be specified in qualitative and/or quantitative terms, often but not exclusively via indicators related to safety occurrences. Examples of the latter include:

a) a maximum probability of an undesirable event, such as collision, loss of separation or runway incursion;

b) a maximum number of accidents per flight hour;

c) a maximum number of incidents per aircraft movement; and

d) a maximum number of valid short-term conflict alerts (STCA) per aircraft movement.

2.3.5 Calculating risk versus accepting risk

2.3.5.1 In spite of all its complexity and limitations, calculating safety risk is a scientific activity which attempts to achieve a true measurement, but deciding on safety risk acceptability will involve a value judgement where consensus cannot always be reached easily as it calls on sociological perceptions, with decisions generally made in the political domain. While utilitarian (i.e. cost-benefit) approaches could contribute positively to the management of safety risk, they can cause legitimate disagreements on safety matters. It will therefore be important to address safety with a clear distinction of the facts and the values.

2.3.6 Expressing risk, measuring safety performance, consistency

2.3.6.1 The different ways of expressing risk and measuring safety performance, as well as the need for consistency, will be of paramount importance in ascertaining levels of safety and constructing safety cases.

2.3.7 Expressing risk

2.3.7.1 There are a number of ways of presenting risk and very significant conceptual differences between them, (e.g. by flight hour, number of operations, time period, for a passenger, flight crew member or the average citizen). It will be desirable to express risk in a stable manner that provides a reference over a period of time in spite of system changes. The best way to express risk will depend on its acceptability by, and distribution among, the population; on its costs, benefits and distribution; on the way it is managed and communicated; and on how it evolves with traffic volume.

2.3.8 Measuring safety performance

2.3.8.1 To satisfy specific requirements as part of the implementation of a safety management system, ICAO Contracting States have agreed to the collection, evaluation and review of safety-related data.

2.3.8.2 To maximize the benefits, such a major task should take into account that simply "measuring" safety will not be an effective way to identify whether safety is satisfactory because it provides too little evidence on the underlying causes and effects, and thus will have little value as a means to prevent future accidents or serious incidents. A better approach will be to analyse the various causes. Their investigation across many accidents and especially recorded incidents will allow the determination of:

a) the relative importance of the various causes;

b) the contribution by the various components of the ATM system;

c) the deficiencies to be corrected;

d) a more robust idea of the current and future safety situation; and

e) useful feedback from experience on the validity of risk mitigation measures.

2.3.8.3 The exchanging of safety information across organizations and States allows for effective collective learning thus adding significant value to all parties.

2.3.9 Consistency

2.3.9.1 The goal will be to develop a consistent approach that can be applied over time and across segments of the industry for the purpose of making informative comparisons.

2.3.9.2 Therefore, as the goal will be to prevent future accidents, investigations must be carried out on multiple hierarchical levels including technical, human, organizational, and regulatory. Since accident/incident models will influence what causes are ascribed and what countermeasures are taken, the model itself will affect very significantly the preventive capabilities. Thus, *causation/prevention models* should in particular:

a) be validated;

b) have good preventive value and link causes with ATM system components and actual preventive measures at multiple hierarchical levels including technical, human, organizational, and regulatory (i.e. a set of meaningful safety indicators which warn of potentially deteriorating situations);

c) use objective, accredited and quality-assured data in sufficient number. This will be of utmost importance to ensure correct analysis conclusions; and

d) encourage the reporting of objective data.

2.3.9.3 Appropriate models (e.g. causation/prevention models) and acceptability criteria (e.g. safety risk (severity/frequency)) will be applied in a consistent manner and supported by *quality assurance principles* within the States' area of responsibility. Their consistent application, over the widest possible geographical area and period, will multiply dramatically the value of the information collected. Thus, as the new ATM concept is adopted globally, the regional sharing of models, criteria and data will become a pre-requisite for further improvements in safety and will likely be supported by ICAO.

2.4 ICAO Universal Safety Oversight Programme

2.4.1 The uniform application of ICAO Standards and Recommended Practices (SARPs) are recognized respectively as *necessary* and *desirable* for the safety and regularity of international air navigation. As signatories to the Convention, States have agreed to respectively *comply* and *endeavour to* comply with them.

2.4.2 Compliance with ICAO SARPs and PANS will be one element in the management of safety.

2.4.3 The ICAO Universal Safety Oversight Programme incorporates as its core function *safety oversight assessment*(s) of States by ICAO, on a mandatory basis, with the objective of offering follow-up advice and technical assistance as necessary to enable States to implement ICAO SARPs and associated procedures (*ICAO Safety Oversight Assessment Handbook*). The programme also covers ATM.

2.4.4 The ICAO Universal Safety Oversight Programme is consistent with the *system safety* approach in that it uses before-the-fact systematic management tools (i.e. audits) during the "operational" life of the SARPs to manage the exposure to risk presented by potential non-compliance. However, the ICAO Universal Safety Oversight Programme is only part of system safety.

2.5 Measuring performance, and the concept of Required Total System Performance (RTSP)

2.5.1 Background

2.5.1.1 In any system, it is necessary to set and measure performance outcomes to:

a) design, develop, operate and maintain a system that can meet the expectations of its users;

b) determine that the system is operating in accordance with its design; and

c) determine when and where action is to be taken to enhance performance levels when the system is not meeting, or is predicted not to meet, expectations.

2.5.1.2 This is also applicable to the ATM system, which is characterized by having to meet stringent minimum levels of performance and by the overriding consideration of safety.

2.5.2 From expectations to performance targets

2.5.2.1 At the highest level, e*xpectations* correspond to an external perception of air transport by the travelling public and the society, and, after proper analysis, can also be expressed as the external perception of ATM by the ATM community. These *expectations* apply to the entire ATM system.

2.5.2.2 A distinction would be made between the general description of a particular *expectation*, e.g. to have a safe system, and a more objective way of measuring its actual or forecast levels and comparing them to levels to be achieved. It is critically important to realize that, even today, there is always a need to balance *Expectations* against each other and against the likelihood to be able to realise a system that can achieve them.

2.5.2.3 Performance measurements would need to be pragmatic and recognize contemporary practice. The definition of the most appropriate measures is a delicate issue. Nevertheless, this is a basic task to make user expectations clear and be able to verify that concepts and planned services can meet them.

2.5.2.4 It may well be that *Expectation* levels will vary over time. At the level of this concept which is primarily focussed on the situation to be achieved in around 2025, *Expectations* should be defined and considered for that time horizon and used to challenge concept statements and proposed features, and as a yardstick for a first validation. The *expectation* levels to be set by Regions and States for actual implementation may differ from those used to prepare the global concept, while contributing to ensure the global cohesion. These may also vary as a function of time depending on the volume of aviation activity and the enhancement of ATM services.

2.5.2.5 The *Expectations* are not independent. For example, there will always be conflicts of interest between individual airspace users for access to the same airspace/runway at the same time, and the economic impact of meeting all needs may translate into unrealistic costs. Trade-offs are, therefore, necessary between *Expectations*. However, safety is always the highest priority in aviation. Therefore, once the acceptable level of safety has been established, it is not subject to trade-offs.

2.5.3 Measurement of performance

2.5.3.1 Care should be taken that the metrics faithfully reflect the nature of the expectations. Metrics should be measurable directly by the ATM Community and should be SMART (specific, measurable, accurate, reliable and timely).

2.5.3.2 It will be critical that the metrics be applied uniformly across the total system. That is, that in a series of linked systems – regions, homogeneous areas, etc. – they will be the same, while the actual required level of performance may be variable.

2.5.4 Meeting performance requirements

2.5.4.1 The ATM System is complex and its behaviour is characterised by a collection of metrics with varying properties (e.g. statistical vs. deterministic, range vs. binary, lag vs. lead, etc.).

2.5.4.2 Therefore, temporary aberrations in performance do not necessarily mean that the system is intrinsically unsafe, uneconomic, inefficient, etc. It can mean that the system is circumstantially not being operated correctly, or that further improvement is required. As an example, accidents or incidents may occur not directly as a result of a total misconception or inadequacy of the system, but as a result of operating a system element incorrectly. This is the source of a significant proportion of the recorded fatal accidents in aviation.

2.5.4.3 Regulators, service providers and service users may choose, for instance, to attack the safety problem at several layers, and arrive at, or agree on a set of values that should not be breached, either in isolation or simultaneously. It is this, among other things, which would determine the usefulness of the metrics. Without these preset limits, there may be a "self justification mode" allowing limits to slide. Therefore any performance management system must not only set rules for performance measurement, but also for performance maintenance, performance management and performance enhancement. In relation to performance assessment, the difference should be made between the levels to be achieved and the monitoring of its achievement, which may lead to specific actions in the case of observed non-compliance.

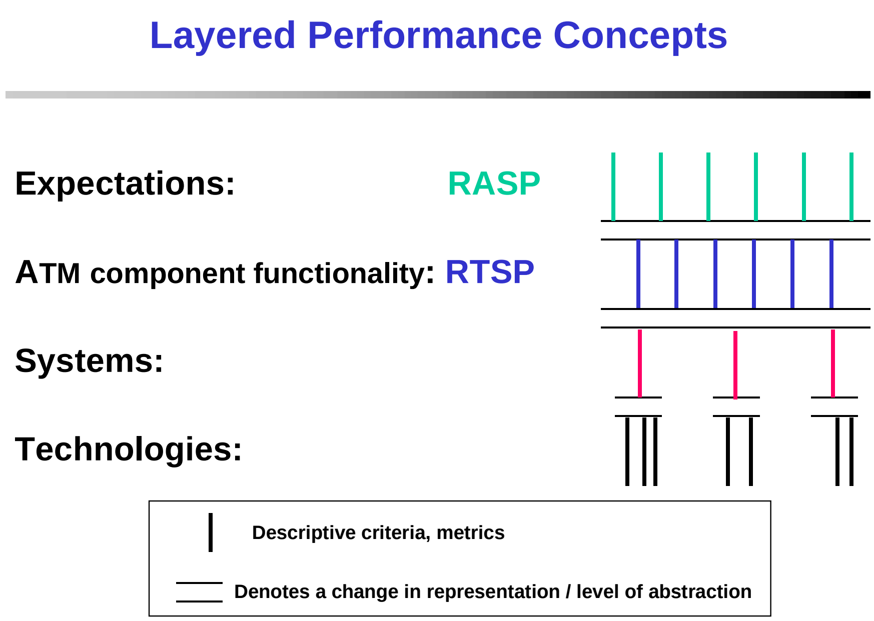
2.5.5 RASP and RTSP in perspective

2.5.5.1 The distinction would be made between the notion of external performance (outcome) to which corresponds the expectations and the internal performance (output) that relates to the functionality of ATM components as they contribute and deliver collectively the required levels of the external performance. The requirements for the former would be expressed as a Required ATM System Performance (RASP), and for the later as a Required Total System Performance (RTSP).By contrast with the *expectations*, RTSP would address an internal perception: what functionality of which quality ATM services, infrastructure, procedures, systems and resources should have and/or aircraft and crews should meet (i.e. impact on the required airborne equipment and crew qualification). If properly implemented and used through the actions of all ATM Community members, achieving RTSP would allow delivery of the RASP.

2.5.5.2 RTSP would incorporate all system capability aspects. It has been historically seen as a compound of required communication, surveillance or navigation performance, for the communication, surveillance and navigation parts, but the proposed definition differs significantly from that view. The following aspects would seem important (subject to confirmation by subsequent work): ATM Services and information required in a given airspace, the interoperability of systems and procedures, and the interface with human operators and associated procedures.

2.5.5.3 The figure below illustrates a potential hierarchy of performance requirements. It shows the transition from RASP to RTSP and then to individual enabling systems and ultimately technologies. It also shows that each transition from one layer to the next would imply changing the nature of the discussion and of the proposed solutions, and a change in representation and level of abstraction. One would migrate from *expectations* to services by defining services that contribute to RASP. Individual enabling systems, like communications, would serve generally several services. Candidate technologies would be practical solutions to realise a particular enabling system.

2.5.5.4 The figure is a simple expression of a more complex reality of interactions that have to be considered when addressing ATM performance and trying to achieve requirements with actual systems.



2.5.6 Expressing and selecting an RTSP

2.5.6.1 The RTSP for a given airspace would be defined by considering the most demanding characteristics of the components for that airspace. This would be accomplished by taking into account the different flight phases, homogenous and routing areas, and traffic density and pattern, as well as the effects of particular environments or situations.

2.5.6.2 Nevertheless, the selection of a particular operational concept feature for the considered time horizon would not be totally independent from the availability of adequate technical solutions. In addition, it should not lead to radically different solutions for different traffic/geographical environments. In other words, the determination of RASP and RTSP is not a blind top-down process ignoring subjacent technologies, and there is a need for interaction between designers of the overall ATM concept and of its more detailed components.

2.5.6.3 ATM can be viewed as a series of layers, from strategic planning to tactical real-time action, which involve various components applied as successive filters to ensure that traffic is safely managed. The layers progressively approach real time decisions, requiring increasing accuracy and critical data. Conflict management, along with the tactical aspects of aircraft navigation and flight management, carry the most stringent requirements and would likely drive the RTSP.

2.5.6.4 RTSP would be expressed as a specific combination of component requirements that would be individually addressed and determined by input from relevant groups or panels and whose collective ability to deliver the expectations should be validated by suitable means.

2.5.7 Elements of the RTSP

General

2.5.7.1 The exact services to be provided will remain a national/provider issue. The service level should be adapted to the needs of the users. A commercial passenger airline does not necessarily have the same requirements as a hang glider pilot. So, several service level agreement levels (e.g. ranging from those for commercial airliner to those for uncontrolled air activity) could be defined.

2.5.7.2 Although not all aspects of ATM would necessarily be subject to common requirement on a wide scale, there would nevertheless be a minimum set of characteristics that would have to be specified, in particular as they impact on the ability to satisfy the various *Expectations.* For example, to ensure that continually changing flight and service provider crews, easily and routinely satisfy *Interoperability* and *Safety expectations*, common operational procedures would need to be implemented globally. To satisfy *Interoperability*, systems would need to be standardised globally at a functional level; but to simultaneously maximize *Cost Effectiveness*, they would need to be standardised also at technological one.

2.5.7.3 The following *potential* aspects, *inter alia*, could be the subjects of required performance:

a) safe separation minima;

b) ATM service delivery time: The timeliness of its delivery, and the effectiveness of what is provided, gauge the performance of an ATM service;

c) strategies for demand and capacity balancing and traffic synchronisation in a given airspace (level of service integration for demand and capacity balancing; strategies to handle network effects);

d) level of integration of information management service; it is probable that a required information performance could be defined;

e) quality of meteorological data;

f) airspace types; need to provide which ground ATM services;

g) data services/applications for air-ground exchanges;

h) flight notification conditions/processes: use of airspace, central or multiple addresses for flight notification filing, required advanced notice, data quality.

i) flexibility of the system (e.g. reaction to weather);

j) coordination levels (ground-ground), with flight data to be exchanged and ground-ground communications;

k) possibility to make use of area navigation capabilities; possibility to use user preferred routing; rules for national interest airspace constraint;

l) procedures, e.g. speed stability or use of time (4-D) in ATM;

m) human performance. Humans within the ATM system must demonstrate appropriate competence at all levels. Such competence should continuously be monitored and frequently tested, and competence regimes should be established sufficient to provide an assurance of human performance. Appropriate mechanisms may include licensing, certificates of competence, technical qualification, training certificates or similar.

n) automation and human machine interface: a minimum level of interoperability would be defined to ensure the smooth flow of traffic;

o) automated functions such as: multi-radar tracking, correlation of radar track and flight plan, distribution of strips, automated co-ordination between sectors or between centres.

p) navigation service: navigation performance may specify certain horizontal navigation accuracy. There may be other aspects to specify, e.g. the definition of turns for accurate navigation, which take high importance in terminal airspace, the accuracy of height keeping, etc;

q) environmental requirement compliance.

2.5.8 Nominal versus degraded modes

2.5.8.1 This is another potential subject of required performance. The operation of ATM when a part of its services is in a degraded mode would have to be considered carefully. Degraded modes should be identified and analysed to determine how the individual services possibly need to be adapted or reconfigured and how to mitigate the degradation. This would have an impact on the RTSP. For example, by addressing alternative concepts in case separation provision is degraded from its nominal mode. The system architecture and system design play here a vital role to maximize the proportion of operation time where it is possible to meet nominal performance requirements, in particular through considerations of system degradations, redundancy and system design features (e.g. defences against cascade and common mode failure).

APPENDIX G

EVOLUTION TO THE OPERATIONAL CONCEPT

1. INTRODUCTION

1.1 Within the planning horizon, it is expected that all States and regions will evolve their ATM systems to meet the balanced expectations of users within the framework of this operational concept. The migration to the concept objectives will be evolutionary, and will involve different levels of emphasis on each of the concept components by States or regions to meet immediate or intermediate objectives, based on specific user requirements at the time. This section provides guidance on the migration process.

1.2 The operational concept is adaptable to the operational environment of all States or regions by being scalable to meet their specific needs. One State or region, or a specific area or location within a State, may have an immediate imperative to improve safety, while another State or region may have an immediate imperative to improve efficiency. The available ATM system components and services are detailed in Chapter 2 and the performance framework that encompasses their particular ATM system is defined in Appendix F.

1.3 States or regions cannot combine or implement the components in a non-standardized way. The concept components should be seen as fixed and standardized; each must be considered within a system design, but the weighting or desired "outcome contribution" of each may differ.

1.4 The concept was developed recognizing that solutions may vary from State-to-State or region-to-region. Within a State, localized requirements, *inter alia*, mass rotary wing operations, space launch areas etc. may predicate changes in emphasis in the ATM system within that area. In all cases, however, the solutions must be interoperable.

1.5 The objective throughout the evolution to the concept objective is to constantly consider that target when planning each evolutionary change. A strategic planning process that identifies the steps that are required to get to the concept achieves this.

1.6 The key issue is to eliminate, to the maximum extent possible, the need for duplication of ATM functionality within aircraft and/or ground systems. The solutions chosen by a State or region need not be technologically complex. Simple solutions, *inter alia*, changes to airspace organization and management, alignment of procedures, or strategic adjustment to flight schedules, etc. may achieve significant benefit in some States or regions. Others may require high levels of automation and technology.

2. USING THE CONCEPT COMPONENTS

2.1 The integration of the concept components can be balanced to achieve different expectation outcomes.

2.2 A useful conceptual diagram, based on the principle of scalable response, is shown below (G-1). The diagram illustrates the framework within which the "outcome contribution" of each concept component is determined. It also illustrates that the range of responses using the seven concept components is variable over a wide range, to achieve desired outcomes.

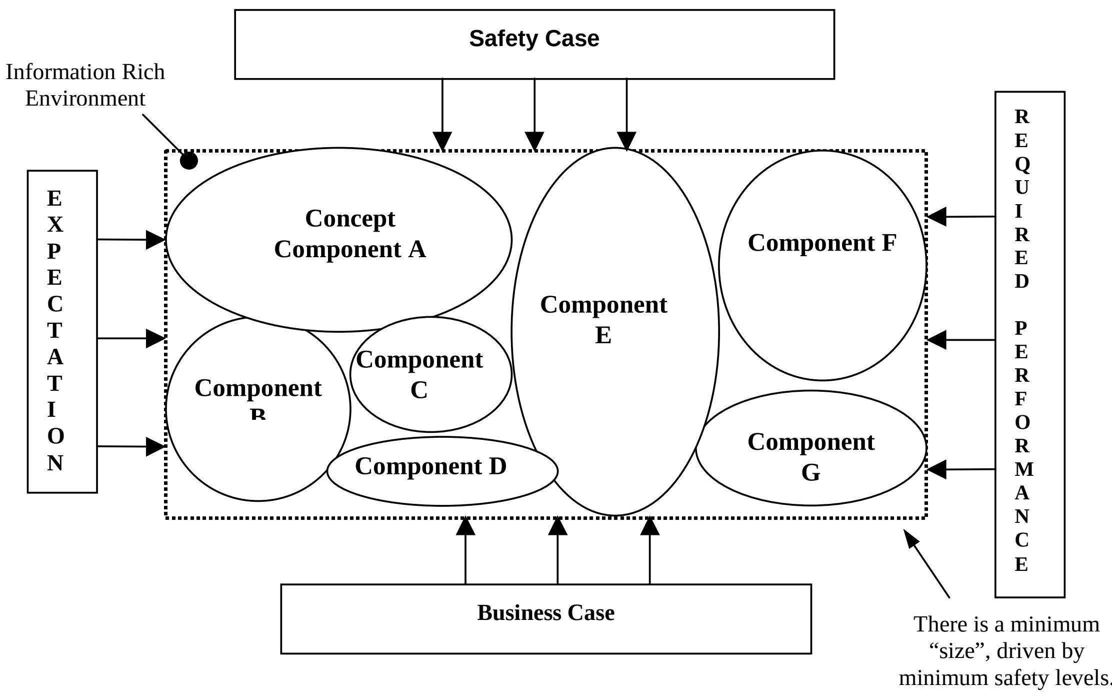


Figure G-1. "Scalable response"

2.3 The size of the box in the diagram is determined by safety and business cases as well as by user expectations and required ATM system performance. It is reasonable that user expectations will remain somewhat constant particularly, when considering the concept objectives. Safety case and required ATM system performance analysis will present a range of potential solutions. Cross-ATM community cost/benefit analysis and business case — and the need for interoperability, will ultimately drive the chosen solution in any given State or region.

2.4 The "bubbles" in the diagram represent the standard concept components. Their relative sizes represent the degree of emphasis that is assigned to each component at a planning point in order to achieve a desired outcome.

2.5 All concept components must be present in each State or region's ATM system to some degree. That is not to say that any particular component will be used as a major contributor to outcome in a particular State or region, or that a great deal of automation or technology will be required to deliver against that component; however, they must be considered at each evolutionary stage.

2.6 There is a further constraint. Safety can never fall below minimum accepted levels. In fact, it should be argued that any change to the ATM system for an outcome not directly aimed at enhancing safety should, nonetheless, strive to achieve its net increase. This is illustrated in Figure G-2 below.

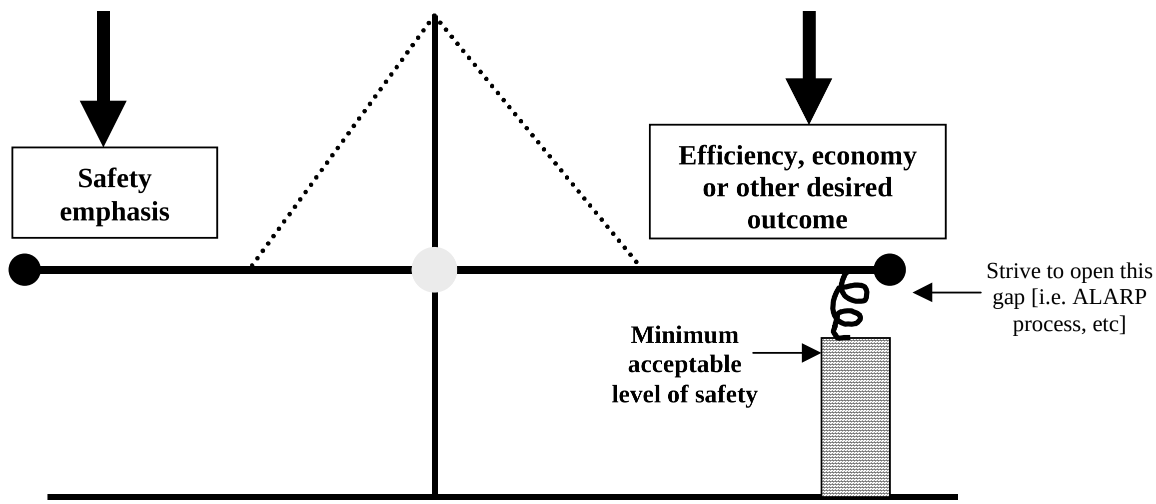


Figure G-2. Safety balance model

2.7 The safety balance model indicates that on the whole, the system needs to retain a safety tension; that is, notwithstanding having achieved an acceptable level of safety, all members of the ATM community must continually explore ways to improve safety.

3. PLANNING APPLICATION

3.1 The functionality of the components cannot change; however, the degree of emphasis placed on the use of those components at any particular time in any given States or regions implementation can change. The "scalable response" approach provides a model that allows various States or regions to adjust and test the effectiveness of changing the degree of emphasis placed on any of the concept components.

3.2 The result is uniform application of concept components between States or regions thus facilitating harmonization and interoperability.

3.3 Figure G-3, below, illustrates a global implementation, at some point in the evolution to 2025.

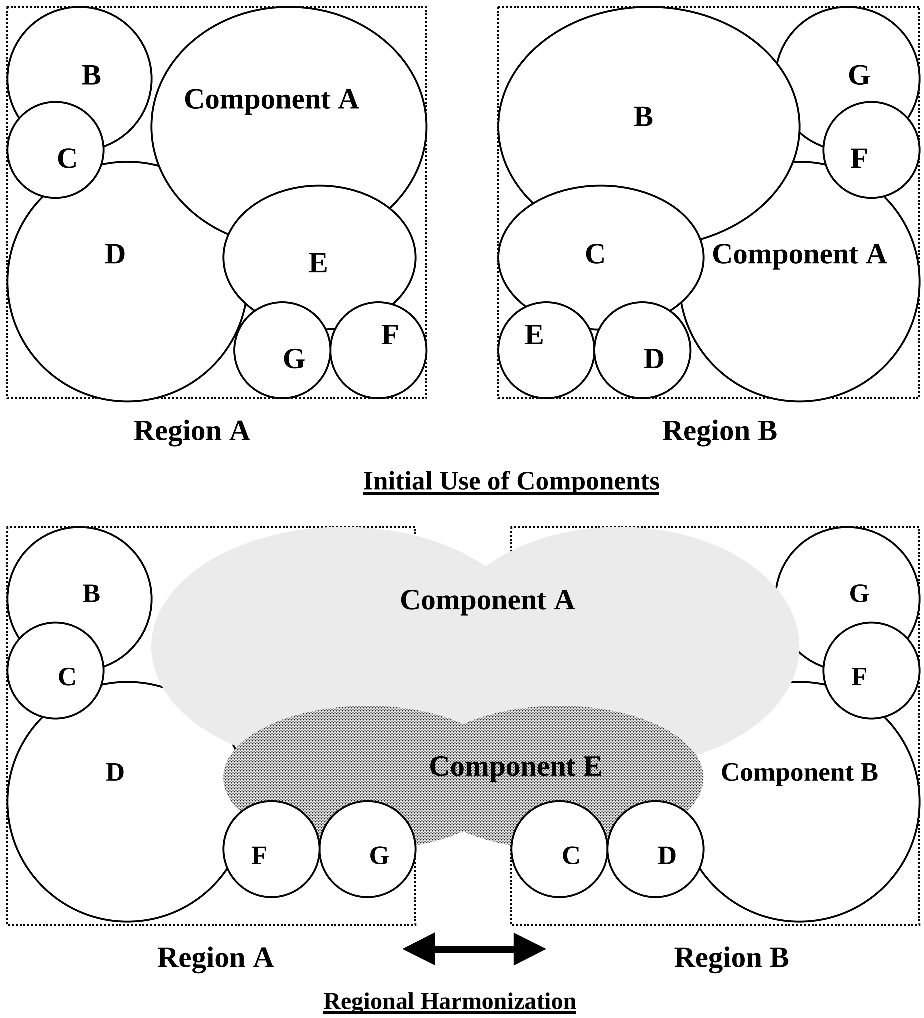


Figure G-3. Global integration

3.4 A key issue to be considered is the need to ensure that the outcome objective of a particular State or region does not impact on the overall objective of a seamless, globally interoperable ATM system. There are two keys to solving this potential issue. The first is ensuring that the "building blocks" (the concept components) are applied uniformly. The second is collaborative decision-making within an information rich environment.

3.5 During the evolution to the concept, aircraft will necessarily transit between States or regions, where desired outcomes differ, and therefore the emphasis on concept components differs. In order to ensure that they can operate seamlessly, the global ATM system needs to be networked into an information rich environment, facilitating the uniform application of the concept components from region to region, and interoperability. This is illustrated in Figure G-4 below.

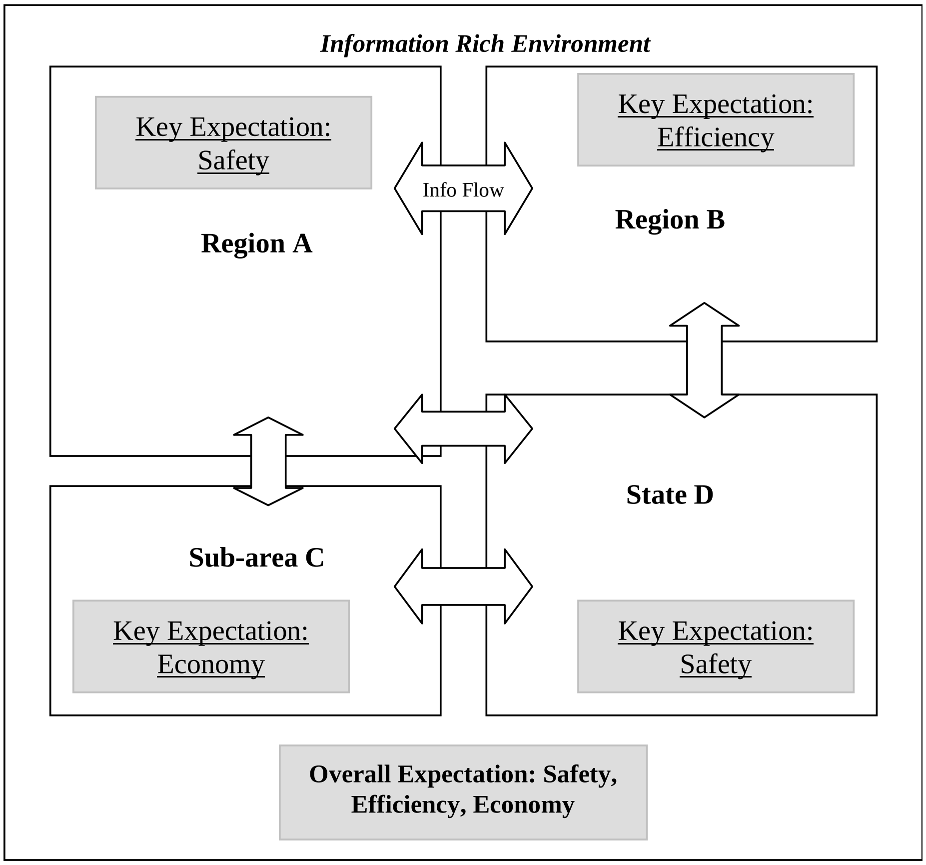


Figure G-4. Network

3.6 The benefit of this approach is that each State or region can assess its current state of development and assess which focus will achieve the best evolutionary outcome — i.e. it allows the mapping of a transition strategy.

3.7 The planning framework to determine the required outcomes for a particular State or region in moving towards the concept goal are more complex than current planning processes. They require a level of strategic collaborative decision-making by all of the partners in an open and collaborative environment. The cost/benefit analysis and business case process will expose areas where resources may not currently be applied to the maximum benefit of the current ATM system.

3.8 The safety case process will expose points of weakness in the system that may require change to the desired outcome, and a change of emphasis, for instance, from economy to safety.

3.9 The current framework of planning and implementation regional groups (PIRGs) requires business case and cost/benefit analysis processes to be applied. ICAO has developed appropriate guidance material in this regard. This must be complemented by a system safety approach.

APPENDIX H

PLANNING

1. INTRODUCTION

1.1 This appendix describes the relationship between the operational concept and the planning process. The planning process at the global, regional and national levels should provide a well-understood, manageable and cost-effective sequence of improvements that keeps pace with user needs, culminating in a system meeting safety, capacity, efficiency and environmental demands.

1.2 The 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. This appendix addresses all three levels of planning: global, regional and national, all of which must be adequately addressed and integrated in support of a seamless, global ATM system.

2. FORECASTING

2.1 Planning for the implementation of ATM systems must begin with a thorough understanding of the requirements of the users of the system. Accurate forecasts of civil aviation activity must therefore be developed in order to support air navigation systems planning activities. In addition to understanding user requirements, investment in new systems requires convincing data to sustain the validity of any proposals associated with that investment. Forecasting in support of ATM planning therefore involves assessment of future trends in aircraft movements, passenger and freight traffic.

3. PLANNING STRUCTURE

3.1 Planning takes place at global, regional and national levels. Planning is accomplished with the help of planning tools and methodologies that are used primarily at the regional and national levels conditioned by guidance from the global level. The basis for effective ATM planning is the ATM operational concept, which should support the development of regional and national ATM implementation plans that will support systems architectures.

4. GLOBAL PLANNING

4.1 The operational concept describes the future ATM services that will be considered in the further development of the Global Plan that reflects the evolution of system requirements. The operational concept will also be used as a foundation for the further development of SARPs and ICAO guidance material in the technical and operational fields.

4.2 Regional planning

4.2.1 The Regional Air Navigation Plans set forth the requirements for facilities and services to support international air navigation. The operational concept will form the basis of regional air navigation planning. It is here that the top-down approach, comprising of global guidance and regional harmonization measures, merges with the bottom-up approach consisting of system architecture and implementation plans of States and aircraft operators.

4.3 National planning

4.3.1 While ICAO addresses the planning strategy at the global and regional levels, planning at the national level is the responsibility of the States. National planning documents should be developed by each State. These may include national system architectures and ATM implementation plans. In addition to describing domestic requirements and implementation plans, national plans should also meet the international requirements as prescribed in the regional plans.

5. PLANNING FOR IMPLEMENTATION

5.1 It is considered that planning could best be achieved if it were organized based on ATM areas of common requirements and interest, taking into account traffic density and level of sophistication required. As a pre-requisite to developing an ATM plan, it is therefore necessary to identify specific planning areas on the basis of homogeneous ATM areas or major traffic flows/routing areas. This would be followed by an operational analysis and the identification of ATM objectives for those areas, using the operational concept as the basis. The results of this effort should lead to a logical set of infrastructure requirements to support the ATM objectives identified.

6. OPERATIONAL ANALYSIS

6.1 An operational analysis is a necessary part of ATM implementation planning and culminates in the identification of the operational requirements and, by establishing criteria to rate alternatives against, leads to the selection of a solution which should be the most effective in fulfilling the ATM objectives as defined in the operational concept. A method for conducting an operational analysis is described in the Global Plan. When evaluating potential improvements to the global ATM system, appropriate alternative analyses should be completed when selecting the optimum approach to improve the ATM system.

7. PLANNING PROCESS

7.1 A complete planning process begins with an operational analysis that identifies the weaknesses and/or opportunities in relation to the present system, followed by development of a strategy containing the high level objectives of the desired system. An operational concept would then provide the basis for development of more specific objectives and a system architecture would identify the technologies and modes of operation of the system to be built to meet the stated objectives. The architecture will form part of an ATM implementation plan.

8. GENERAL TRANSITION ISSUES

8.1 As stated above, the migration from the present system to the more advanced ATM systems is based on technologies that should be carefully planned. Assurance is needed at each step that continued levels of safety would be maintained — and improved upon where necessary. The demonstrated capabilities of new systems must be made clear to the members of the ATM community that must make investments in new systems so that they would be encouraged to make the necessary investments to equip their fleets, or to install the necessary infrastructure at the earliest opportunities.

APPENDIX I

ILLUSTRATIONS OF THE CONCEPT

1. INTRODUCTION

1.1 In order to assist understanding the operational concept, some explanations and examples are provided in this appendix to illustrate what air traffic management may evolve to.

1.2 These illustrations are not meant to constrain the vision to one particular interpretation but rather provide examples of possible interpretations of the concept. Further examples are being prepared and will be distributed separately.

1.3 The concept requires integration of all concept components within the operating environment of each region, acknowledging that regions will apply different emphasis to concept components to achieve the desired outcomes. To assist understanding of each component, individual component illustrations have been provided. Additional illustrations, such as on collaborative decision making, are also provided.

1.4 The operational concept presents a vision for the future ATM system that is not constrained by current technology. Transition to that vision is intended as an evolutionary process.

2. ILLUSTRATION: AIRSPACE ORGANIZATION AND MANAGEMENT

2.1 Airspace organization and management will be dynamic, flexible and increasingly tactical in application.

2.2 Airspace organization and management requires close collaboration between airspace users, the airspace organization and management service provider and other ATM service providers, to ensure, to the maximum extent possible, equity and access. Strategic airspace organization and management relies on pragmatic identification by users of their specific requirements, so that constraints or requirements for the use of any particular airspace volume can be minimized. Restrictions on user operations are only imposed when safety requires, or the ATM community agrees that certain procedures are appropriate for efficiency of the ATM system, or a State identifies a particular national interest. Once the circumstances generating a requirement for constraints or requirements cease, the airspace restrictions will be released.

2.3 In order to ensure that the level of constraints on the ATM system imposed through airspace management are kept to a minimum, awareness of activities within all airspace is required as part of on-going monitoring, and adjustments to airspace organization and management are made as required. In this sense all airspace is monitored, but to an appropriate level as determined by safety assessment within a safety management program. Monitoring takes place in a number of ways. It can occur in advance of activity, *inter alia*, by assessment of flight schedules or statements of intent, discussions with potential airspace users, or notification by States of national interest requirements. It can occur dynamically, through co-monitoring (with other service providers) of tactical surveillance data. It can also occur post-activity, by assessment of actually flown flight trajectories, with the intent of refining airspace organization and management techniques.

2.4 Airspace will ideally be organized and managed in such a way as to facilitate the use of full self-separation and autonomous flight unless safety or efficiency assessment requires the provision of separation services. This must be achieved in conjunction with, or anticipation of, demand and capacity balancing techniques, to ensure that the potential for aircraft-to-hazard conflict is reduced to a level where such self-separation is expected to be able to be conducted to an accepted level of safety.

2.5 Techniques may include, *inter alia*, the promulgation of fixed or dynamic segregated departure and arrival tracks to aerodromes, the implementation of segregated fixed or dynamic route structures, the implementation of dynamic 4-D trajectory systems, the coordination of hours of activity of national interest airspace constraints, and so on. It may also include the promulgation of certain user requirements — such as minimum capabilities, or hours of access — to mitigate risk. A primary tenet, however, must be that any such restriction or constraint, where possible or practicable, should be transient, and other users should be accommodated when the constraints are no longer required, or the levels of risk allow.

2.6 The ATM system is subject to a number of uncontrollable or unpredictable events that can affect ATM. In particular, weather and natural phenomenon, including lines of thunderstorms, standing waves and clear air turbulence, snow on runways, volcanic ash, and so on, will continue to have significant consequences on user operations. Airspace organization and management service providers will react to these uncontrollable events by redistribution or re-organization of airspace to maintain maximum efficiency. This is an example of tactical airspace organization and management.

3. ILLUSTRATION: AERODROME OPERATIONS

3.1 In order to comprehensively consider the role of aerodrome operations within the ATM system, aerodrome operations will be considered from an en-route to en-route perspective.

3.2 Constraints on flights moving from the runway to the parking location, and from the parking location to the runway are minimized. System enhancements to minimize constraints include:

a) enhancement of communication capabilities to airspace users at an increasing number of airports improves information exchange and coordination activities, and increased collaboration and information sharing between airspace users and service providers creates a more realistic picture of aerodrome departure and arrival demand;

b) automation aids for dynamic planning of surface movements provide methods and incentives for collaborative problem solving by airspace users and service providers. This improves the management of excess demand through balanced taxiway usage and improved sequencing of aircraft to the departure threshold. In addition, support tools permit the optimization of take-off points along the runway, by accessing information on aircraft performance capabilities such as required take-off distance, and climb-out capabilities. This also applies in the case of arriving aircraft, allowing exit points from a runway to be accurately predicted, or realistically assigned.

c) integration of surface automation with departure and arrival automation facilitates the coordination of all surface activities. Runway and taxiway assignments are based on projected arrival/departure runway loading and surface congestion, airspace user runway preference and parking location. Environmental considerations, such as noise abatement or emission minimization, will also be taken into account to the extent that safety is not compromised. Arrival runway and taxiway assignments are planned early in the arrival phase of flight. Departure assignments are made when the flight profile is filed, and updated accordingly until the time of pushback.

d) surveillance and guidance systems for greater situation awareness that permit full capacity operations in all weather conditions.

3.3 The ATM environment is increasingly integrated as surface-movement decision support systems provide real time data to the ATM environment-wide information system. When the aircraft starts moving, the flight's time-based trajectory is updated in the ATM environment-wide information system, based on the estimated taxi time at the airport under prevailing traffic conditions. When the aircraft becomes airborne, this trajectory is again updated. This continuous updating of the flight object improves real-time planning for both the airspace user and the service provider. Real-time information also improves the effectiveness of ongoing traffic management initiatives and the collaborative decision making involved with any proposed initiatives.

3.4 Surface-movement decision support systems are also an integral part of the total ATM environment automation system. This ensures that surface initiatives and user preferences are not at cross-purposes with information being generated by airspace automation systems. Thus, runway assignments in departure and arrival automation are based not only on the location of the assigned parking location, but also on the surface automation's prediction of congestion and the related taxi plan. For departures, taxi time updates and the associated estimates included in the taxi plan are coordinated automatically with airspace automation to efficiently sequence ground traffic to match projected traffic flows aloft. Conflict management on the airport surface benefits from increased information to improve situation awareness, support taxi planning, and improve ramp management to match surface movement with the departure and arrival phases of flight.

3.5 Taxi planning is significantly improved through timely availability of traffic activity information. As the aircraft prepares to taxi, decision support systems are used to determine taxi sequencing, and to perform conformance monitoring and conflict checking. Since this automated planning process shares information with the surface situation monitoring systems, the resulting taxi plan balances the efficiency of the movement with the probability it can be executed without change.

3.6 For departures, the decision support system incorporates departure times, aircraft type, wake turbulence criteria, and departure routes to safely and efficiently sequence aircraft to the departure threshold. For arrivals, the decision support system considers the intended parking location to minimize taxi time after landing. Additionally, improved knowledge of aircraft intent allows automatic monitoring of taxi plan execution and provides alerts to the potential for runway incursion.

4. ILLUSTRATION: DEMAND AND CAPACITY BALANCING

4.1 Collaborative ATM system design and implementation will provide an agreed system capacity level. Available capacity will vary due to several factors including uncontrollable events, for example weather-related turbulence.

4.2 Demand and capacity balancing actions, aimed at ensuring safety, equity and access will be a collaborative decision making process in which the collection, collation and analysis of data to produce an accurate picture of the demands and constraints that will affect any particular airspace volume will begin long before the day of operations. The degree of automation or sophistication required in the processes would reflect the performance requirements or expectations of a particular volume. A series of optimized airspace structures and forecast traffic models for the entire usable airspace volume may be required. In these plans, the allocation of airspace will be balanced between the needs of particular users, including, *inter alia*, commercial, general and military aviation.

4.3 In any particular environment, the planning processes may be divided into three major phases:

a) strategic planning — involving the long-term activities to produce a coordinated strategic plan of demand and capacity up to (or in some cases more than) one year in advance;

b) pre-tactical planning — involving the modification of the coordinated strategic plan; and

c) tactical planning — involving final modifications to the plan.

4.4 In some environments, the volume and complexity of data to be processed so as to produce the operations plans would require the support of advanced decision support systems, aiding the development of plans at each level. Other environments may be assessed manually on the basis of operational experience, or on the basis of historical analysis. In either case, the results would be available to all affected partners and would contribute to transparent negotiation and agreement. Data on planned flights, the weather, ATM capacities and capabilities would come from many sources in and beyond the affected airspace volume, and would need to be collected, collated and analysed to provide the refined data needed to build up the analysis or simulation layers supporting each planning phase. That analysis would then be able to determine the effects of any proposed changes on the safety, capacity and efficiency of the system and then to assist the planners in modifying the plans to resolve any problems.

4.5 Strategic planning

4.5.1 The strategic planning phase could commence at any time in advance of a particular airspace activity. Whilst full schedule information might not be known until some months or weeks before a particular flight, certain data is available many years in advance, and aids in pre-planning. This could include, *inter alia*, historic demand from scheduled and non-scheduled flights, airspace availability or constraints, ATM resource availability (capabilities and capacity estimations) and the impact of operational changes (new procedures, new standards, ATM and airport facilities availability, approximate estimates on the weather conditions for the season and estimations of likely business and other non-forecast airspace users demands. This data could be used to aid airspace organization and management processes. In this sense, airspace organization and management could be engaged as a strategic demand and capacity balancing tool by adjusting capacity.

4.5.2 The main benefit to be gained through a strategic planning phase is that processes would be improved, developing from a tactical or reactive system to one which would be strategic or proactive, and one in which predictability would be improved and which would allow the maximum possible flexibility and economy of operations for the user in normal conditions. Procedures would be established to best suit the traffic flows and to assist traffic separation by the creation of discrete system trajectories which would be re-configurable in line with the different demands on airspace at different times of the day and night. ATM may be required to establish airspace management regimes and route structures to maintain or improve safety levels, capacity and efficiency in the use of airspace and of runways.

4.6 Pre-tactical planning

4.6.1 During the pre-tactical phase, data received from all users and service providers, such as confirmations, modifications, cancellations and additions, that could affect the plan, would be received, analysed and incorporated. The plans developed in the strategic planning phase would be progressively refined and expanded, taking into account user preferences for flexibility, punctuality or service quality requirements. The plans would provide a framework that gives a good forecast of the traffic demand and the users' capabilities and resolves conflicts of interest between those parties and user groups that plan their activities up to years in advance. At the same time, the plans also estimate the reserve capacity and airspace needed for those airspace users who, due to the tactical nature of their operations, cannot plan well in advance. In addition, the plans sets the rules and parameters, which broadly outline everyone's access to airspace, routes and airports, and provides estimates on the reserve capacity that may be needed for each day's traffic situation.

4.6.2 In some environments, the plans may be published and further developed into regional, hour-by-hour, plans that are finalized and promulgated at an agreed time before operation. The plans contain, for example, statements of flight intent, airspace regimes and reservations plans, route configuration plans and service provider service limitations, capabilities and capacities. In other environments, plans would be developed on a less formal basis, but with the same intent of better matching capabilities with demand and capacity.

4.7 Tactical planning

4.7.1 At some stage prior to the flight, the user would have determined the flight trajectory that will best address the user's operation and would submit the user requested trajectory to the demand and capacity balancing service provider for assessment and agreement. The tactical planning phase examines a flight request to see if it is acceptable or if there are any potential resource, capacity or congestion problems of which the user was unaware. If there were problems, demand and capacity balancing would identify user-preferred solutions, giving the user the freedom to choose the most optimum flight within the system constraints. If however, safety levels or equity might be compromised, protocols would establish the demand and capacity balancing service as the final arbiter in the determination of system delivered trajectory.

4.7.2 Real-time information, such as the weather forecasts, traffic demand and airspace reservations, would be used on a continuous basis to predict en-route and terminal capacity and traffic densities for the remainder of the day, update the hour-by-hour forecast of local capacity bottlenecks throughout the region(s), and assess the impact on the complete flight trajectory of individual flights (i.e. from gate-to-gate).

5. ILLUSTRATION: TRAFFIC SYNCHRONIZATION

5.1 Traffic synchronization is the establishment and maintenance of a safe, orderly and efficient flow of air traffic in all phases of flight.

5.2 In the departure phase of flight, traffic synchronization involves the integration of departures into the airborne traffic environment. Improved departure flows are achieved through tools that provide more efficient airport surface operations and improved real time assessment of traffic activity in departure and en route airspace.

5.3 In the en-route phase of flight, traffic synchronization involves the sequencing, integration and spacing of en-route flows, to reduce reliance on tactical conflict management. Improved flow sequences are achieved through tools that provide more efficient prediction of demand and capacity at crossing points, improved real time assessment of traffic activity in departure arrival airspace, increased usage of airborne equipage to maintain group spacing or station keeping, and expanded usage of dynamic routes based on the use of enhanced navigation capabilities.

5.4 Arrival operations also benefit from these tools, however the primary task in this phase is to plan and achieve optimum spacing and sequencing of the arrival flow. The runway assignment, which provides the basis for this activity, is made as early as possible. The user's runway assignment preference is available through the flight object within the ATM environment information system. Departure and arrival decision support systems and the integrated surface management tools are used to coordinate an optimal runway assignment.

5.5 In the final portion of the arrival phase, decision support systems facilitate the use of time-based metering to maximize airspace and airport capacity. Other tools generate advisories to aid in manoeuvring flights onto the final approach in accordance with the planned traffic sequence.

5.6 In all phases, a service provider may give the pilot responsibility for station keeping, or a time to cross a point or points, to maintain the required sequence and traffic flow.

6. ILLUSTRATION: AIRSPACE USER OPERATIONS

6.1 The concept uses the term "airspace user" to recognize the diverse nature of missions and demands on the airspace resource, for example military, airlines and general aviation.

6.2 This section illustrates the airspace user's interaction with the ATM system. See also collaborative decision making.

6.3 ATM system design

6.3.1 The airspace resource is considered to be finite and the capacity of the airspace resource depends on the procedures and tools employed. There will be conflicting demands between airspace users, therefore the issue of resource management that provides acceptable safety, equity, access and efficiency is a major consideration.

6.3.2 There will be no ATM restrictions on user missions except where required due to safety or ATM system design. ATM system design will minimize restrictions, but recognizes that efficiencies can be achieved by some regulation and that some special needs, such as security requirements, must also be addressed.

6.3.3 Each airspace user is a member of the ATM community and is expected to participate or have representation within collaborative decision-making processes that affect their missions, including ATM system design processes. The ATM system design will give due consideration to and be largely based on users' expectations. It should be noted that any changes to ATM system design will include ATM system-wide safety, business, environment and security cases. System-wide cases will contribute to increasing regional and global interoperability and harmonization.

6.3.4 The concept recognizes the mutual inter-relationship between aircraft design and ATM performance. The ATM system will be designed to accommodate a wide variety of mission requirements, including a wide range of aircraft types and performance. Some efficiency in the ATM system can be best achieved through aircraft design, as indicated by system-wide safety and business cases.

6.3.5 In this illustration, the airspace user prefers no ATM requirements constraining their desired mission. All ATM services will be on a "on-request" basis, however safety or ATM design requirements may require the use of a particular service. ATM system design will determine where and when services will be available.

6.3.6 The airspace user initially accepts responsibility for all aspects of their mission, including conflict management, unless ATM system design requires services to be requested. Conflict management recognizes that conflicts are not just between aircraft but also between a mission and any hazard. In addition, the larger the conflict horizon the increased likelihood that the user's mission can be more efficiently conducted.

6.3.7 Cooperation

6.3.7.1 A spirit of cooperation is expected within the community that permits an acceptable level of information and airspace resource sharing. The user is not necessarily required to provide all the information requested by the ATM system, as the user can determine different levels of participation, however not sharing of some information may result in increased ATM restrictions on particular missions.

6.3.7.2 All users should consider that the demand on the airspace resource for their particular mission is temporary. This will ensure the equitable use of the airspace resource amongst all airspace users.

6.3.8 Trajectory negotiation

6.3.8.1 Where the airspace user's mission is a flight, then the airspace user will communicate their specific mission requirements using a 4-D flight trajectory to the level of accuracy required by the ATM system. Advance notice of the flight, to a lesser level of detail, may have already been provided to aid ATM system design and configuration, including determining available ATM services and for demand and capacity balancing.

6.3.8.2 Where an ATM service is used, the user will always communicate their preferred 4-D trajectory. If the user is aware of restrictions that prevent the preferred trajectory, then the user may also propose the preferred alternative trajectory.

6.3.8.3 If the requested trajectories were not immediately available, then the demand and capacity service provider would then negotiate with the user and, through collaborative decision making, work towards an agreed trajectory.

6.3.8.4 This trajectory would be approved with tolerances, which constitutes a "4-D trajectory contract" between the airspace user and the service provider. The airspace user can accept or reject the proposal, as part of the collaborative decision making process.

6.3.8.5 The intent of these tolerances, which can vary over trajectory, is to allow some freedom of changes within the trajectory that can be made by the airspace user without further reference to the service provider. The tolerances are intended to provide as much flexibility as the ATM can allow, while balancing the requirements of other airspace users.

6.3.8.6 After the trajectory has been agreed, when there are changes in ATM resources that affect the aircraft's trajectory then collaborative decision-making will consider alternative trajectories. If time permits this may be consideration of several options, but if time is limited then this process may instead be based on pre-agreed procedures and preferences.

6.3.8.7 After the trajectory has been agreed, if the airspace user's requests a trajectory change, then the requested 4-D trajectory will be communicated to the ATM service provider and the collaborative decision making trajectory negotiation cycle commences again.

6.3.8.8 Effective information management and sharing enables easy and rapid collaborative decision-making negotiation between airspace users and ATM service providers, since the airspace user and service providers have access to the same information on the current and forecast ATM system status.

6.3.9 Performance incentive and assistance

6.3.9.1 When the airspace user is unable to meet ATM system requirements to operate a particular flight at a particular time because of some performance or equipment lack, the ATM service will, in many cases, be able to offer services to the airspace user that mitigate the deficiency for that mission.

6.3.9.2 Procedures will be collaboratively developed that provide an incentive for airspace users to improve ATM performance. These procedures should not prevent access to airspace for users suffering equipment failure or wishing occasional use of the airspace, if the ATM system is capable of safely handling the deficiency.

6.3.9.3 Note that the performance required to operate in a particular airspace is dynamically managed and the airspace user may also choose to operate at another time when performance requirements are less and so avoid the need for any additional service from the ATM system.

6.3.9.4 An example of this assistance may be the requirement for the user to broadcast position and intentions, which an equipment deficiency prevents. The ATM system may be able broadcast this information on behalf of the airspace user using ATM surveillance capabilities to determine aircraft position, intent information supplied to ATM service provider by the airspace user and the service provider's broadcast equipment.

7. ILLUSTRATION — AIRLINE FLIGHT

7.1 The following material provides some illustrations that relate more to airspace users engaged in airline operations. It is not intended to be a complete description and applies to a particular interpretation. Other airspace users may follow similar ATM processes.

7.2 The airspace user may initially — as early as several months to a year before flight — provide information on intended operations, with accuracy appropriate to the planning stage, to the demand and capacity balancing service to allow strategic airspace organization and management.

7.3 When the availability of forecasts allows meteorological flight planning, the airspace user would negotiate the user-preferred 4-D trajectory with the demand and capacity balancing service of the ATM provider. The 4-D system proposed trajectory is defined in terms of the lateral, longitudinal, and vertical components of the aircraft position, and the time of the position information. It includes route, altitudes, speeds, and — where feasible with respect to the planning horizon — runway and arrival times taking into account weather, airspace constraints, aircraft performance capability and user constraints such as schedule.

7.4 The system offered trajectory — complete with departure time, weather data, way-points with estimated time/altitude/speed is communicated to the flight deck, for acceptance. The pre-departure system delivered trajectory — i.e. the trajectory finally accepted— is stored for access by all potential ATM service providers.

7.5 Based upon the flow of outbound traffic, the aerodrome operations service provider may amend the initial trajectory to define a safe and expeditious flight-path through the departure phase of flight, where interaction with other departing or arriving aircraft may occur. The departure clearance is communicated to the flight deck as well as authorization to start the engines and, where applicable, push-back. The aircraft would taxi along routes that have been designated to eliminate conflict between departing and arriving streams and to prevent potential queuing or congestion problems. Aircraft take-off performance itself — for example a high rate of climb — may be used as a means to discriminate departure traffic from arrival traffic and to mitigate environmental constraints.

7.6 The user preferred trajectory is a route of flight most closely matching user expectations. The system delivered trajectory will always attempt to match those expectations as closely as possible. Notwithstanding that the delivered trajectory may effectively release the aircraft to a self-separation mode, or to a free-routing mode, the delivered trajectory is also taken into account within the ATM system in determining demand and capacity balancing, conflict management and aerodrome operations performance. Un-forecast changes in trajectory can impact the operations of other aircraft. To that end, the current position of the aircraft and its predicted trajectory, as required by ATM system design, are routinely communicated to other partners in the ATM system for strategic or tactical ATM purposes.

7.7 Any deviation from the initial system delivered trajectory is negotiated directly between the flight deck and the ATM service delivery management. Such deviations may be generated as a result of factors including, *inter alia*, unforecast weather, unpredicted activation of airspace constraints, destination arrival delays, the need for conflict management and resolution, changes in airspace capacity, changes to aircraft performance, or emergency situations. In a free routing environment, a clearance or authorization to deviate or amend trajectory would not be required — however, any amended trajectory would be dynamically provided to the system to provide decision support to other ATM processes or partners.

7.8 Where the ATM system is providing a flight monitoring — or other — function for an aircraft, the potential for flight optimization may be detected by the ATM system, and offered to the airspace user. Any revised routing will be negotiated to be free from conflicts, or where self separation has been invoked, any potential conflict identified within the trajectory parameters would be clearly enunciated to the flight deck in the trajectory offer. Where trajectories are being negotiated, the flight deck can assume that such negotiations are for the whole of the intended en-route phase of flight unless specifically stated.

7.9 The arrival phase of flight is characterized by the flight transition from the en-route environment into the terminal and aerodrome environment using an arrival route or procedure, the approach and landing, and the taxiing to the parking location. The proposed arrival trajectory will have already been allocated on the basis of known departure and en-route trajectories, aircraft performance and known constraints within the terminal and aerodrome environment, minimizing potential for delays, and optimising aerodrome capacity. Unforecast events may impact the arrival trajectory — however, any delays should have been absorbed within the en-route trajectory. Arrival trajectories would be segregated from departure trajectories, and such segregation may be based on aircraft performance characteristics. Aircraft performance characteristics — including wake vortex, and slowing and stopping capabilities — and runway design characteristics — including high-speed exists and precision guidance capabilities — will have been taken into account in determining safe spacing for traffic synchronization to the runway and on the runway.

8. ILLUSTRATION: CONFLICT MANAGEMENT

8.1 In this illustration, the need for airspace users to achieve maximum efficiency for flights is a high priority, whether it is a required time of arrival or most economical operation. It is recognized that tactical changes to flight trajectory in order to address separation from hazards or to wait for access to an ATM resource to become available both have significant impacts on flight efficiency. The ATM system therefore has determined that negotiated 4-D trajectories that require no tactical intervention is the desired goal. It is recognized that certain inaccuracies in the information available and unforeseen or uncontrollable changes will still require tactical modifications to flight profiles. In addition, there may remain in the ATM system design, an element of tactical intervention as a cost effective solution to some ATM issues. Trajectory management aims to achieve the desired time of arrival at the destination parking area.

8.2 Strategic conflict management

8.2.1 Conflict management is to limit, to an acceptable level, the risk of collision between an aircraft and any hazard. The airspace resource management activities of demand and capacity balancing and traffic synchronization obviously have a close connection to conflict management, and are indeed considered to be the strategic components of conflict management. The use of strategic conflict management reduces the need for tactical intervention to an agreed level. Note that the activity of the demand and capacity balancing is efficient resource management and not simply preventing overloading of tactical separation activities, which does not necessarily deliver maximum capacity, as more aircraft may be handled in a smooth sequence than in a sequence that has to be tactically created.

8.2.2 Hazards in conflict management has been expanded to include all hazards to flights, and also to include hazards on the apron. Any solution to a conflict with a particular hazard must confine the solution trajectory to airspace (or an area) free from all hazards.

8.2.3 As the trajectory is managed from gate-to-gate, it is necessary to consider hazards and resources on the apron. The trajectory from when the aircraft starts to move, should aim to be conflict free without delay. The trajectory includes transit from the landing runway to the arrival parking location, which should also aim to be conflict free without delay.

8.2.4 To reflect the move towards more strategic conflict management, that is airspace resource management, the concept defines the term “conflict” as whenever the applicable separation may be compromised. This definition was previously considered as “potential conflict” which reflected more tactical conflict management, which is keeping aircraft away from hazards. In more strategic conflict management, a “conflict” occurs whenever there is a competing demand for the airspace resource.

8.2.5 Separation provision

8.2.5.1 Tactical conflict management, referred to in the concept as separation provision, is the next layer of conflict management. Separation provision has been defined in some detail in the concept and introduces the term separation mode. The concept does not address the development of these separation modes, which requires considerable work. In this illustration, work is still on going on developing additional separation modes, however the concept has been interpreted as having a defined minima for separation from all hazards and having a separator based on intervention capability.

8.2.5.2 Defined separation minima allows not only for a single value in all cases, but also dynamic values which are determined from defined parameters, for example by using a separation minima formula. The need for having defined minima has been necessary for the development of decision support tools, which required values by which hazards must be avoided.

8.2.5.3 Intervention capability has, in this illustration, produced different values for different separators and for each separator the value varies on circumstances. A major reason for different values is the total workload required from the airspace users, service provider or automated system. The choice of which is the best separator for a given situation is given due consideration in ATM system design. The airspace user as the pre-determined separator is still the starting point of the design, which is that there is no separation provision service unless safety or ATM system design requires such a service.

8.2.5.4 In this illustration, cooperative separation remains an option available within this particular ATM system, but not a requirement for the separator to use. Delegation occurs only when deemed appropriate by the current separator and after acceptance by the proposed delegated separator. The delegation is for a defined period under defined conditions. As separation provision is tactical conflict management, this delegation and acceptance is in many cases well defined. The procedures were developed from previously existing delegation procedures. An example is the phrase “cleared visual approach”, which according to pre-defined procedures, transferred the responsibility for separation from terrain for an aircraft from the service provider to the airspace user (if the visual approach was accepted), however separation from other traffic remained the responsibility of the service provider.

8.2.6 Collision avoidance

8.2.6.1 In this illustration, collision avoidance systems have continue to evolve however they have remained systems that avoid immediate proximity hazards, rather than systems that have evolved into some form of tactical separation provision. The role of collision avoidance systems are considered an important aspect of the safety design of the ATM system and are therefore considered as part of meeting the level of safety required by the ATM design. The importance of collision avoidance systems, which is the third level of conflict management, is the additional and independent level of conflict management to that provided by separation provision. Note that collision avoidance systems are not considered as an element of the separation modes of separation provision.

9. ILLUSTRATION: ATM SERVICE DELIVERY MANAGEMENT

9.1 The role of the ATM service delivery management coordinates the delivery of services from all service providers, including other ATM service delivery management providers, to an airspace user's request for a service. For example, it may be a single service delivery management that coordinates services from a number of different service providers located over several regions.

9.2 At the strategic level, the ATM service delivery management is responsible for conducting collaborative decision-making within the ATM community to achieve the best outcomes for the ATM community. This includes balancing conflicting requests from different community members. The constraints on choices will be the global safety standards (and any additional requirements from the States), which must be met. Within these constraints, the service delivery management service will provide the combination of ATM services that best meets agreed levels of capacity and efficient for the whole ATM community.

9.3 The ATM service delivery management would normally be the first point of contact between a potential airspace user and the ATM services. This may occur directly, through a collaborative decision making process about levels of service, or indirectly, through the determination by appropriate authorities of the need — or otherwise — for certain services or processes in the absence of an airspace user. The airspace user may also contact individual service providers directly for provision of a particular service, for example for a short-term need.

9.4 Although ATM services are available on request, it may not be efficient to supply all services in all airspace. Therefore it will be necessary for the community to agree when services will be available, subject to safety and business cases.

9.5 For example, as traffic levels increase in areas where no ATM conflict management services were previously required there are a number of options to maintain the required safety level. They include the requirement for a separation provision service (tactical conflict management) at peak times, or demand capacity balancing (while self-separation continues) or particular procedures. It may be determined that the problem is localized with no consequences for international operators and that the most effective solution is a procedural one.

9.6 The ATM service delivery management will assess the availability of other ATM service providers to effect a particular service. At a strategic level, this may entail accessing capabilities from adjacent providers, or conducting analysis work in support of business and safety case for system enhancements.

9.7 Where required, appropriate automated decision support tools will support ATM en-route services. Many of these systems will be aimed at conformance and safety monitoring.

9.7.1 Phases of flight

9.7.1.1 In the departure and landing phase of flight, ATM service delivery management will be responsible for ensuring that flights can get to the runway in time for their take-off slot and at the same time to integrate them with all the other departing and arriving flights in order to ensure safety and to optimize the use of the parking locations, ramps, taxiways and runways. The ATM service delivery management will ensure that service providers are given access to real-time data on projected arrivals and departures, runway loading, airport congestion, parking locations and environmental considerations, in order to reduce the inefficiencies in aircraft and vehicle movements.

9.7.1.2 Within the en-route phase of flight, ATM service delivery management will be involved in matching ATM service capabilities with demand — e.g. traffic flow characteristics — by a range of means, including, *inter alia*, dynamic re-sectorization in ATM service centres, changes to route structures or airspace organization, or changes to conflict management modes.

9.7.1.3 During the course of a flight — from its inception at a scheduling or planning stage, through its actual operation, to its completion at an arrival parking location — ATM service delivery will consider the objectives for any particular flight in the course of operations from gate to gate. The degree to which these objectives are evident during a flight and the interaction required is a function of both traffic volume and flight duration.

9.7.1.4 For illustration, phases of flight for ATM service delivery management might consist of:

a) planning — where the objective is integration into the ATM environment to achieve a close match between user preferred trajectory and system delivered trajectory;

b) ramp — where the objective is to move the flights in and out of the parking locations;

c) surface-departures — moving aircraft from ramp to departure queue;

d) departure — where the departure queue and the runway are managed to launch aircraft from the queue into the airspace;

e) dispersion — which as its name implies, objective is to get aircraft up and out of the terminal into the en-route structure;

f) cruise — in which the aircraft is at altitude and moving towards its destination, but it is not yet subject to actions related to its arrival phase;

g) collection — the state in which aircraft are sequenced and spaced to bring them into the terminal area for arrival;

h) approach — in which aircraft are assigned to runways and onto the surface;

i) surface-arrival — moving aircraft off runways and to the ramp; and, once again

j) ramp — working the aircraft into the parking location.

10. ILLUSTRATION: COLLABORATIVE DECISION MAKING

10.1 Collaborative decision-making allows all members of the ATM community, especially airspace users, to participate in ATM decision-making that affects them. The level of participation reflects the level to which the decision will affect them.

10.2 Collaborative decision-making applies to all layers of decisions, from longer-term planning activities through to real-time operations. It applies across all concept components of the ATM system and is an essential element of the operational concept.

10.3 Collaborative decision-making is achieving an acceptable solution, which takes into account the needs of those involved. All participants therefore require a spirit of cooperation. A balance is required because collaborative decision-making is primarily invoked to resolve competing demand for an ATM resource and to organize a safe sharing of that resource between airspace users.

10.4 The time available for achieving a collaborative decision decreases from strategic to tactical. In the most tactical of situations, there may be no time for consideration of options however, wherever such situations can be foreseen, collaborative decision making will have been previously used to have determined agreed procedures for such cases. For example, rules for determining priorities for access to an ATM resource will have been collaboratively agreed in advance. Therefore collaborative decision-making can be applied both actively and, through agreed procedures, passively.

10.5 Effective information management and sharing will enable members of the ATM community to each be aware, in a timely manner, of the needs, constraints and priorities of other members in relation to a decision-making issue.

10.6 Collaborative decision making can occur between airspace users directly, without any involvement of an ATM service provider.

10.7 Any member of the ATM community can propose a solution

10.7.1 Where a service provider is involved in collaborative decision making because of a requirement of the ATM system, it is often the ATM service provider who will propose a solution for consideration of the airspace user, as the service provider is aware of the requirements of other users and service providers and the collaboratively agreed rules for resolving competing requests for an ATM resource. However, because it is an information rich environment where the airspace user may have access to the same information as the service provider, the airspace user will understand why the particular solution is proposed.

10.7.2 If time permits, a user can propose an alternative solution that addresses a user's preference that is not known to the service provider. In the same way the service provider can reject the user's proposed solution because of an ATM requirement that the user is not aware of. This illustrates how important full sharing of appropriate information is in order to have timely collaborative decision-making.

11. INFORMATION MANAGEMENT

11.1 The ATM operational concept envisages application of a system-wide information management concept, where information management solutions will be defined at the overall system level, rather than at each major sub-system (program/project/process/function) and interface level individually as has happened in the past.

11.2 System-wide information management — or simply information management — aims at integrating the ATM network in the information sense, not just in the system sense. This fundamental change of paradigm forms the basis for the migration from past one-to-one message exchange concept to the future many-to-many information distribution model. That is, many geographically dispersed sources collaboratively updating the same piece of information, with many geographically dispersed destinations needing to maintain situational awareness with regard to changes in that piece of information.

11.3 Information management will ensure that the information needs of ATM stakeholders — both within as well as outside the ATM network — will be satisfied in a much more flexible and cost-effective manner than previously.

11.4 This goal will be achieved by integrating the capabilities of all suppliers of ATM information, to assemble and continuously maintain the best possible integrated picture of the past, present and (planned) future state of the ATM situation. This will be used as a common basis for improved decision making by all ATM stakeholders during their strategic, pre-tactical and tactical planning processes, including real-time operations and post-flight activities.

11.5 Successfully managing the quality, integrity and accessibility of this complex, growing web of distributed, fast-changing, shared ATM information called the virtual ATM pool, could be considered to be the main operational enabler for the operational concept.

11.6 Decision-making is a normal operational process, but decisions will be of a better quality and engender greater confidence because accurate and validated information will be available in the right form, in the right places and at the right times. An open systems environment and better information management will allow information sharing on a much wider basis than hitherto, and will support a permanent dialogue between the various partners, throughout all phases of flight.

11.7 The exchange of information will enable the various organizations to update each other continuously on events in real-time. Thus, aircraft operators will have up-to-date and accurate information on which to base decisions about their flights, while ATM service providers, including aerodrome operators, will have a better knowledge of flight intentions for operational and planning purposes.

11.8 Other interested parties who need information to improve the service that they supply to — or receive from — ATM, including, *inter alia*, customs and immigration authorities, meteorology departments, baggage handling and so on, will benefit from more accurate arrival, departure or trajectory information. The combinations of partners involved in any particular decision process may be numerous. For example, some decisions will concern just the airport authority and aircraft operators (refuelling times, parking bays etc.), whereas others will need to involve all parties (changes to departure times, etc.).

11.9 Information management may be conceptually subdivided into information ownership, licensing and pricing, information security management, ATM pool content management, the information acquisition process and the information dissemination process.

11.10 Information will be a commodity in the future information-rich ATM network, not just in the strategic planning phases, but also during real-time operations. However there will be commercial sensitivity and national security considerations, as well as the interests of commercial information service providers.

11.11 Information ownership, licensing and pricing are issues which are related to, but distinct from security and communication cost aspects. Certain ATM information provided by stakeholders within or outside of the ATM network will be able to be shared without restrictions. For other information, the suppliers may want to charge a fee, restrict dissemination and/or retain ownership and control after dissemination.

11.12 Arrangements will have been made to establish security levels, the willingness of stakeholders to provide certain information, gain access to information, play certain roles in collaborative decision-making, and compensate or charge the stakeholders accordingly in financial or other terms.

11.13 Protocols will have established the legal basis; for daily operational application they will be translated into appropriate ‘adaptation parameters’ governing the continuous operation of the various information management sub-processes throughout the ATM network.

11.14 In a collaborative distributed environment, where technical, organizational and institutional barriers to the access of information have been drastically reduced, security will be of utmost importance. Consistent and compatible mechanisms will exist to handle the security aspects of information collection, content management and dissemination throughout the ATM network. The principle of subsidiary will be applied in security matters: for example physical storage and security management that may be as close as practicable to the information owner.

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