

Doc 9882
AN/467



Manual on Air Traffic Management System Requirements

Approved by the Secretary General
and published under his authority

First Edition — 2008

International Civil Aviation Organization

Published in separate English, French, Russian and Spanish editions by the International Civil Aviation Organization. All correspondence, except orders and subscriptions, should be addressed to the Secretary General.

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Chapter 1

OVERVIEW

1.1 RELATIONSHIP BETWEEN ATM SYSTEM REQUIREMENTS, PERFORMANCE-BASED TRANSITION GUIDELINES AND GLOBAL PERFORMANCE

1.1.1 This document, together with the *Manual on Global Performance of the Air Navigation System* (Doc 9883), provides a comprehensive understanding of the intent of, and delivery mechanisms for, the ATM system envisioned in the *Global Air Traffic Management Operational Concept* (Doc 9854).

1.1.2 The *Global ATM Operational Concept* (OCD) presents a vision for an integrated, harmonized and globally interoperable ATM system planned up to 2025 and beyond. While the operational concept is visionary and challenging, many of the current practices and processes will continue to exist through the planning horizon. In this sense, the operational concept document is evolutionary.

1.1.3 *Global Performance* (Part I of Doc 9883) focuses on the performance dimension. It describes a process for developing performance objectives, metrics and indicators in the context of overall ATM system behaviour responding to ATM community expectations. The manual provides guidelines for setting performance objectives and targets, as well as for monitoring, evaluating and forecasting ATM system performance.

1.1.4 The *Performance-based Transition Guidelines* (Part II of Doc 9883) address the evolutionary nature of the operational concept. They provide guidance for transition from the baseline system of 2000 to a “mature-state” performance-based system envisioned by the OCD for 2025 and beyond. The strategy is based around delivering continuous and incremental performance enhancements.

1.1.5 As is indicated in 1.1.2, many current practices and processes for the ATM system will continue through the planning horizon. This document reflects this reality and identifies requirements where a significant change to operating practices will be required. Hence, the requirements set are not intended to be exhaustive and are relatively small compared with other requirement-source documentation across the spectrum of operations envisioned in the OCD.

1.2 DOCUMENT INTENT

1.2.1 The evolution and enhancement of the ATM system will be directly related to the ATM community's ability to clearly define performance expectations, set a relevant performance framework, set achievable targets and implement change cost-effectively, based on capabilities at any particular time along the planning horizon.

1.2.2 This document aims to define high-level requirements (hereafter referred to as ATM system requirements), supporting the OCD, and is to be used in conjunction with the OCD from which the requirements were derived. The ATM system requirements shall be applied in developing Standards and Recommended Practices (SARPs) to realize the concept. These requirements will also be used by the planning and implementation regional groups (PIRGs) as well as States to develop transition strategies and plans at regional and State levels. The ATM system requirements will generally be stable over time; that is, they represent the fundamental characteristics/attributes required of the ATM system.

1.2.3 The improvement in demonstrated (overall system) performance associated with these ATM system requirements reflects the evolution of capabilities.

1.2.4 ATM system performance will not progress as the direct result of the requirements; rather, the system is performance-driven, and levels of performance will differ in response to the demands of differing operating environments, in particular, a State, group of States, or regions.

1.2.5 This document supports the ATM community in establishing a globally harmonized, performance-based system in its service, according to regional and national plans, but consistent with the OCD.

1.2.6 The requirements set out in this document are relatively small. This is because many of the requirements that define the ATM system are constant; that is, they have existed since the ATM system first came into existence and will continue through its continued operation. What changes is the performance outcome demanded of a particular requirement. As an example, the statement "... the ATM system shall perform safely ..." is a requirement statement that has applied to the ATM system in the past, applies in the present and will continue to apply into the future. In fact, the change comes from the definition of required performance outcome and the ability to measure whether or not that outcome has been achieved.

1.2.7 In 1950, a safety performance outcome may have been stated as a certain number of accidents per year and measured subjectively or objectively. In 2000, both the safety target and the means of monitoring it were defined more stringently (e.g. × fatal accidents per flight hour per dimension for the en-route phase of flight). In the planning horizon, the performance goals will become more stringent, and delivery mechanisms and processes will change; but the basic requirement (to perform safely) remains constant.

1.2.8 In this context, the ATM system requirement statements in this document reflect mainly those areas in which a change in direction is needed to achieve the vision outlined in the OCD. It is therefore necessary to evaluate the operation of the current system — together with the new requirement statements — when assessing any evolution of the ATM system. In some cases, the requirements in this document build on changes already initiated by ICAO in the development of communications, navigation and surveillance/air traffic management (CNS/ATM) systems and may be seen as retrospective requirement statements.

1.3 DOCUMENT STRUCTURE

1.3.1 The requirements section of this document (Chapter 2) provides ATM system requirements and supporting material viewed against the ATM system as a whole and against each of the seven ATM system components and information management as identified in the OCD and shown in Figure 1-1. The ATM system requirements should be read in the context of expectations detailed in the OCD and reproduced in Appendix E to this document. Chapter 2 contains the following subsections:

- a) Performance and expectations, Information management and services, and System design and engineering: These subsections contain requirements that may be described as transcending several concept components or applying across the whole ATM system. These requirements may also be reproduced directly or adapted in specific component areas to qualify as specific requirements of a particular component.
- b) ATM system components: Included are seven subsections matching the OCD components and common elements. Each subsection briefly describes what the component does from an operational perspective. The intent is to give the reader a broad context statement on the requirements. However, the reader still needs to interpret the requirements in the context of the entire OCD, including its appendices. Each subsection also includes a set of the ATM system requirements relating specifically to the components and common elements. Where appropriate, they have been collated into sections of like requirements with explanatory text, if considered necessary or helpful.

1.3.2 Each requirement statement has an associated identification number (R and the number). Requirements connect to the OCD via the linkage matrix in Appendix A. In many cases, explanatory text is included to answer questions readers may have in reading the requirement(s). Explanatory text appears as either direct clarification or statements of intended use, as envisioned by the authors of the OCD.

1.3.3 The intent of the requirement set is to reflect the nature of the OCD itself, that is, to ensure that the reader is aware that the ATM system exists as a holistic entity and not as a set of individual elements. This is discussed in Section 2.1.1 and illustrated in Figure 2-1 of the OCD.

1.3.4 In short, this means that even though a specific component may have a small number of requirements, the requirements must be read together with the whole set and interpreted in the context of the other requirements so that evolution of the ATM system is globally harmonized and integrated.

1.3.5 Note that the organization of requirements into the various sections is to facilitate understanding and not prioritize the importance of requirements based on their location in the document. The structure eases reading and reference comprehension within the context of the OCD's description of an integrated and interdependent ATM system.

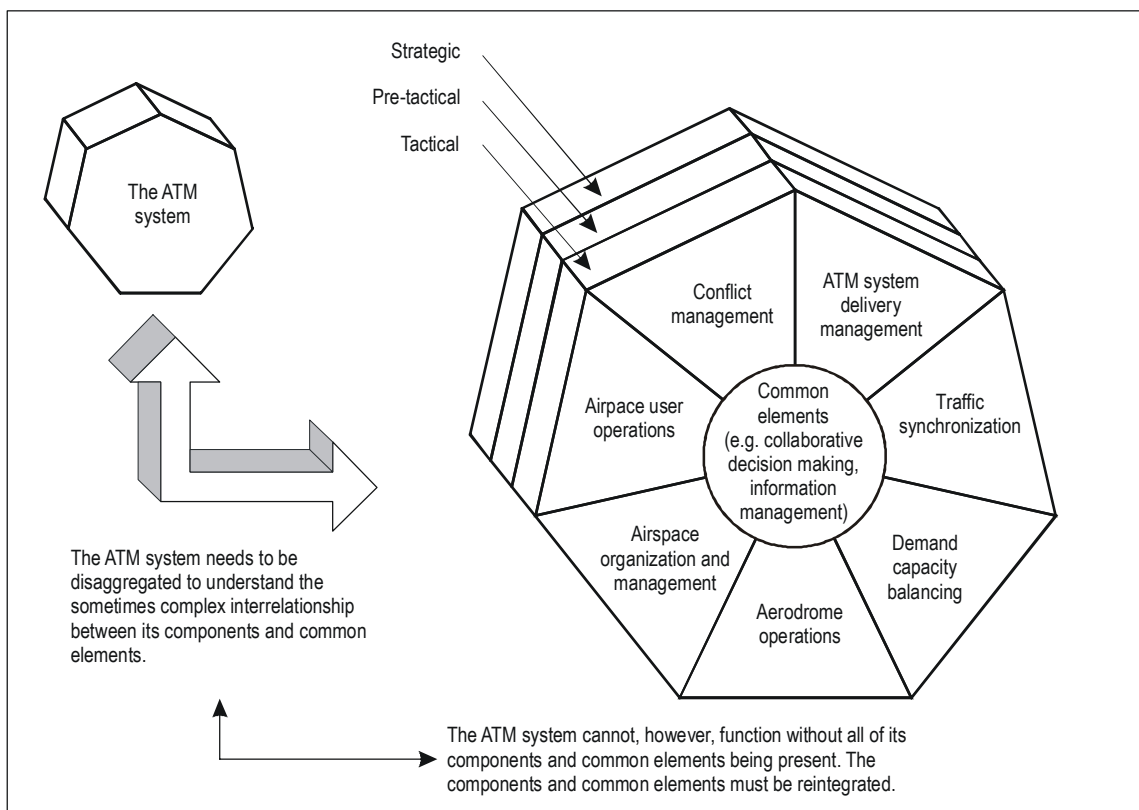


Figure 1-1. ATM system components

1.4 DESCRIPTION OF THE ATM SYSTEM REQUIREMENTS

1.4.1 An ATM system requirement is a statement of functionality and/or operating characteristics necessary to fulfil the expectations and deliver the benefits envisioned in the application of the OCD. The characteristics of ATM system requirements are:

- a) Each requirement uses the words **shall** or **will** for “base” elements of the OCD.
- b) Each requirement uses the word **should** for “desirable” elements of the OCD.

Note.— In this context, “base” refers to elements of the OCD that are necessary to ensure coherent performance across the entire global ATM system. Their level of effect on the performance of the ATM system in a particular State, region or other operating area may vary, depending on the expected performance outcomes agreed collaboratively.

- c) The requirements were generated as an extraction of the OCD.

Note 1.— The level of detail is expected to be finer than the OCD, but coarser than what would be found in a SARP or global system design document.

Note 2.— The words “will” and “should” have imperative status only when written in requirement statements and not when included in the explanatory texts accompanying a requirement statement.

- d) Elements of the extraction that are not directly evident in the OCD will only be those that are logical derivatives (e.g. the OCD inclusion of a timely action will clearly be dependent on the delivery, in a timely manner, of information to support the action).
- e) The scope of qualifiers (for example “all”) will not exceed those contained in the OCD.
- f) The scope and extent of the requirements are intended to be comprehensive in addressing the elements and components of the OCD. However, the requirements are neither intended to provide a complete system specification nor to imply that a design choice has been made.

1.4.2 Further, the requirements will provide guidance for development of SARPs. SARPs will be progressively developed or amended through the transition period to achieve enhanced ATM system performance and global harmonization, as envisaged in the OCD.

1.4.3 The ATM system requirements will also set the scope for transition strategies to be adopted by States or regions. Some States or regions may from time to time adopt different strategies to achieve the required performance outcomes, always adopting improvements from a common roadmap.

1.4.4 The ATM system requirements will establish a framework for the elements of performance that will be descriptive in nature and not set quantitative values/targets.

Chapter 2

ATM SYSTEM REQUIREMENTS

2.1 PERFORMANCE AND EXPECTATIONS

2.1.1 General

The global ATM operational concept envisions a system that is service-oriented, performance-driven and predicated on the guiding principles described in the OCD (*Global Air Traffic Management Operational Concept*, Doc 9854). To fulfil this vision, the ATM system shall:

- a) ensure that performance forms the basis for all ATM system development [R97a)];
- b) treat performance as a whole, that is, considering all the ATM community expectations and their relationships [R185];

Explanatory text: The holistic treatment of performance should be done by means of a system performance approach resulting in performance cases. A performance case can be seen as the combination of the various cases that together address and balance all areas in which the ATM community has expectations, e.g. the safety case, together with the business case, together with the environment case.

- c) ensure the establishment of performance cases (safety, business, environmental, etc.) before implementing changes [R186];
- d) ensure that performance targets are defined, regularly reviewed and monitored [R97b)];
- e) establish interchange of global benchmarking performance data as a cornerstone of ATM system management [R97c)];
- f) ensure that all information for performance management is available to the concerned parties transparently and that information disclosure rules are in place [R187];
- g) ensure that any performance management system establishes rules for, among other things, performance measurement, performance maintenance, performance management and performance enhancement [R103];
- h) establish quality of service requirements to support provision of services within the ATM system [R158a)];
- i) ensure that quality of service includes performance requirements related to availability, continuity, reliability and integrity [R158b)]; and
- j) balance the expectations of the ATM community [R188].

Explanatory text: The ATM system will consider the trajectory of a vehicle during all phases of flight and manage the interaction of that trajectory with other trajectories or hazards to achieve the optimum

system outcome with the minimal deviation from the user-requested flight trajectory, whenever possible. The ATM system will provide seamless service to the user at all times and will operate on the basis of uniformity throughout all airspace. Uniformity embodies both application of common ATM system rules and procedures across all airspace and use of common core technical functionality in the systems used.

It is not intended that this will establish an all-embracing requirement for identical equipment or systems, although minimizing system duplication or reducing equipment or systems needed to operate in a global ATM system environment is an obvious goal.

It is intended that agreed required minimum levels of aircraft equipment, performance and ATM system network capabilities will be matched by defined levels of service. It is intended that the ATM system should provide all users, at a minimum, the same level of access to runways and airspace when compared to a regionally agreed baseline year.

2.1.2 Safety

Safety is a key and constant performance expectation of the ATM system. To meet this expectation, the ATM system shall:

- a) be based on the principle that the safety of the ATM system, or its components and parts, is evidence-based [R134];
- b) define common safety indicators to be used by all States [R141];
- c) ensure that safety data will be recorded, processed and analysed centrally within a State, region or group of States, taking into account the experience of existing State incident reporting schemes; furthermore, safety data will be shared globally [R175];
- d) ensure a consistent approach to the collection, evaluation and review of safety-related data, including the understanding of causes and effects that can be applied over time and across segments of the community for the purpose of making informative comparisons [R192];

Explanatory text: This does not mean that all community members use the same approach but, rather, that they can communicate by sharing a wide, diverse, and yet common set of models, assumptions, definitions, and so on.

- e) support system safety with lead indicator and causal factor analysis, in addition to traditional lag indicator statistical analysis in the ongoing monitoring of safety [R135];
- f) ensure application of the system safety approach to all life-cycle phases of the ATM system and its elements, supported by safety cases [R174];
- g) ensure that all safety practices and processes are explicit and that they comply with the safety requirements and standards of ICAO, State regulatory authorities and other appropriate parties [R102];

Explanatory text: ATM system performance requirements should be based on the key understanding that the ATM system is a collective integration of parts, including humans, information, services and technology. When contemplating or undertaking a change to a particular part of the ATM system, whether at the local, State, regional or global level, one must give due consideration, through a safety case, to the potential effect on adjacent parts of the system. The decision regarding the level of assessment will be made pragmatically, but transparently. In establishing safety management systems, determining safety targets and conducting safety cases, the accumulated effect, on safety, of those parts — in addition to the individual effects — should be taken into account.

- h) ensure that ATM system safety is maintained during any transition [R140];
- i) establish contingency plans at all levels of operation to deal with anomalies/disruptions and to ensure safety and an appropriate level of operations [R131];
- j) be designed so that the operation and continued evolution of the ATM system incorporates mechanisms so that information and/or actions concerning emergency and/or unexpected events involving any of the airborne or ground-based ATM community members can be communicated to all ATM system participants who need to respond to or be aware of the event or actions [R162];

Explanatory text: An enhanced capability will be provided to disseminate information regarding emergency situations to appropriate ATM community members so that the necessary response actions and intervention can be initiated more effectively.

- k) accommodate the determination of levels of safety and risk which may be expressed in various manners [R190];

Explanatory text: There is no single and universally valid way of expressing the level of safety or risk. It is however desirable to express safety and risk in a manner that provides reference over time despite system changes.

- l) ensure that the target level of safety is the minimum level of safety to be achieved [R193];

Explanatory text: The ATM system recognizes that absolute safety cannot be achieved; however, it should always be a desired goal. In the evolution of the ATM system, safety targets will be established reflecting a continuing desire to improve current levels of safety. In setting safety targets from time to time, each organization, State, region, or global group should generate a better safety outcome than the previous target within practicable limits; that is, all components of the ATM system should strive to reduce incidents and accidents and increase positive safety indicators.

- m) recognize that there are three safety risk bands: intolerable, as low as reasonably practical (ALARP), and broadly acceptable [R189];

Explanatory text: The safety industry generally recognizes that there are situations in which the continuous range of possible levels of safety cannot be divided into only two bands, "intolerable" and "broadly acceptable". There is a third, intermediate region between these two levels. Where such an intermediate region exists, the question becomes how to make decisions if the level of risk falls within that region. To make such decisions, the safety industry generally uses the so-called ALARP. This means that measures to reduce risk must be taken until the cost of further risk reduction would be grossly disproportionate to the reduction in risk that would be achieved, hence, the "ALARP region".

- n) ensure that safety risk is calculated with scientific rigour; however, also accommodate the determination of safety risk acceptability by value judgement [R191];

Explanatory text: A distinction should be made between both activities (safety risk calculation and acceptability determination) and their respective boundaries and logic.

- o) be designed so that the human is never in doubt as to the ongoing status of the ATM system or the flight environment as appropriate to the human task undertaken [R138]; and

- p) be designed so that collision avoidance systems remain a safety net independent from separation provision [R194].

2.1.3 Security

Performance of the ATM system depends on security related to both the internal elements of the ATM system — including personnel, infrastructure and data — and the external expectations of the broader community, including national security interests. To meet these expectations, the ATM system shall:

- a) be based on the principle that the operation of the ATM system will not compromise the sovereignty of any State [R184];
- b) ensure appropriate levels of security [R124a];
- c) recognize that the requirements associated with security may vary from time to time and according to location [R124b)]; and
- d) coordinate these requirements through strategic, pre-tactical and tactical collaborative decision making to allow agreed performance parameters to be met by ATM system partners [R124c)].

2.1.4 Cost-effectiveness

To meet the expectations of the ATM community regarding cost-effectiveness, the ATM system shall:

- a) ensure that where they are required, validation and cost-benefit analysis¹ are achieved through focused research and development and establishment of business cases¹ prior to implementation of the changes [R129].

2.1.5 Access and equity

To meet the expectations of the ATM community regarding access and equity, the ATM system shall:

- a) ensure that, in the design of the ATM system, the principles of access and equity are taken into account [R165];
- b) be designed to accommodate all types of airspace user missions and all types of vehicles and associated characteristics [R45]; and

Explanatory text: Any type of user mission will be accommodated, and an appropriate type/level of service will be provided. Different types of mission will — or may have — different planning horizons. The ATM system will accommodate and be able to handle different planning horizons.

It is intended that the ATM system will be able to accommodate a wide variety of vehicles, with a similarly wide variety of characteristics and capabilities, not only based on current knowledge, but also for the evolutionary future. The expectation is that these new types of vehicles, characteristics and capabilities should be accommodated in a manner that achieves the optimum system outcome with minimal deviation from the user-requested flight trajectory when they may appear in the future.

It is expected that unmanned aircraft systems will be operated either remotely by a human operator or execute their pre-programmed mission automatically, and that some of these aircraft systems may not be able to dynamically change their trajectory. It is intended that the ATM system will accommodate such pre-programmed missions after strategic collaboration.

1. Refer to Appendix D for further information on cost-benefit analysis and business case.

It is intended that the ATM system will provide services according to the maximum level of vehicle capabilities.

- c) be designed to minimize restriction of access to airspace [R195].

2.1.6 Capacity

To meet the expectations of the ATM community regarding capacity, the ATM system shall:

- a) provide the collaboratively agreed level(s) of capacity [R196];
- b) ensure that sufficient capacity is provided through collaborative decision making (CDM) [R197];
- c) ensure that the ATM community works collaboratively to plan and implement the capacity needed to cost-effectively meet the forecast demand [R198];

Explanatory text: Through collaboration, ATM community members will determine the appropriate investments and associated commitments to make available the desired capacity of ATM system resources. The investments and commitments include those by both users and service providers. (e.g. "matched" commitments include infrastructure deployment by service providers and equipage or training.)

- d) ensure that all available capacity is fully and efficiently used [R111]; and

Explanatory text: The intent is not to create capacity for its own sake, but to ensure that the available capacity is efficiently used given existing demand.

- e) minimize the impact of adverse weather on the total ATM system so as to ensure that maximum throughput is generated in all meteorological conditions [R199].

2.1.7 Environment

Environmental considerations are increasingly important in ATM system design and will continue to be so through future development of the ATM system. To meet the expectations of the ATM community regarding environment, the ATM system shall:

- a) ensure that environmental issues are considered in the design, development and operation of all aspects of the ATM system [R167];
- b) establish and monitor agreed environmental performance targets to ensure that the expectations of society for the aviation industry contribute to the reduction of impacts on the environment, including noise, gaseous emissions, and the effect on the amenity of particular areas is met [R127]; and
- c) facilitate collaborative decision making between the appropriate community members and appropriate environmental authorities to ensure that an appropriate balance exists between the need to mitigate the effects of the ATM system on the environment, and the economic benefit to States derived from operation of the ATM system [R128].

Explanatory text: ATM system components and the ATM community, when agreeing on performance targets, will consider measures that will not only contribute to a sustainable environment from a purely ATM system perspective, but also in the context of the complete transport value chain as imposed on the ATM community.

2.1.8 Predictability

To meet the expectations of the ATM community regarding predictability, the ATM system shall:

- a) ensure that ATM community members provide past, current and predicted information as required by the system for predictability of services [R176]; and
- b) provide the ATM community with data essential to the planning of its operations [R200].

2.1.9 Community participation

To meet the expectations of the ATM community regarding community participation, the ATM system shall:

- a) be designed in such a way as to ensure that all pertinent ATM community members are included in relevant collaborative decision making and have easy access to the associated necessary information [R180].

2.1.10 Flexibility

To meet the expectations of the ATM community regarding flexibility, the ATM system shall:

- a) implement and operate in such a way that the varying and diverse user requirements will be met as closely as technically possible within the defined equity and access [R181]; and
- b) enable all airspace users to adjust departure and arrival times and modify flight trajectories dynamically and, where necessary, renegotiating trajectory agreements, thereby permitting them to exploit operational opportunities as they occur [R201].

2.1.11 Efficiency

To meet the expectations of the ATM community regarding efficiency, the ATM system shall:

- a) address the operational and economic cost-effectiveness of gate-to-gate flight operations from a single-flight perspective [R202]; and

Explanatory text: 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.

- b) modify the airspace user's preferred trajectory:
 - i) when required to achieve overall ATM system performance requirements; and/or
 - ii) collaboratively with the airspace user, in a manner that recognizes the airspace user's need for single-flight efficiencies [R203].

2.1.12 Global interoperability

To meet the expectations of the ATM community regarding global interoperability, the ATM system shall:

- a) be based on global standards and uniform principles, ensure the technical and operational interoperability of ATM systems and facilitate homogeneous and non-discriminatory global and regional traffic flows [R204]; and
- b) establish common operational procedures within similar operational environments [R205].

2.2 INFORMATION MANAGEMENT AND SERVICES

2.2.1 Information services

Managing information and providing information services are critical to the development of the ATM system envisioned in the OCD. These activities ensure cohesion and linkages between the various ATM components described in the OCD as well as performance expectation areas described in previous sections of this document. To meet the expectations for the ATM system regarding information services, the ATM system shall:

- a) implement system-wide information management [R70];
- b) provide a global, common aviation data standard and reference system to allow fusion and conflation and provide comprehensive situational awareness and conflict management [R06];
- c) establish information exchange protocols and procedures to ensure that appropriate performance can be achieved within the agreed rules [R12];

Explanatory text: These “agreed rules” would be determined through collaborative decision making.

- d) provide to the ATM community accredited, quality-assured and timely information meeting the identified standards of performance, including quality of services [R74];

Explanatory text: It is essential that information does not change character or value as it travels through various systems. It is assumed that information may be combined, segregated or reformatted in accordance with the needs of the end user; however, the content (character, data values, and so on) should not change the context (the environment from which the information originated). In summary, received information content is exactly the same as the information from the originator.

The differences brought about by evolution in technology are not expected to have any impact on the efficient transmission of the information among the ATM community members. The requirements of seamlessness and interoperability dictate that systems — whether proprietary or not — conform to openly available standards regarding the format and character of transmitted or transferred information. It is intended that there will be development of fully interoperable information systems capable of seamless information transfer throughout the ATM system.

- e) provide information systems that identify the nature of the information in terms of timeframe — historical, current or planned [R75];
- f) ensure that a relevant validity period of ATM system information is evident to the user of that information [R79];

Explanatory text: Information that is expected to change over short intervals must have a validity period that is evident to the user of the information. Conversely, information elements that are not expected to change except after system design changes should not need to be repeated at short intervals. The information management system is expected to explicitly reveal the validity period for the demanded information.

- g) be capable of collecting and integrating information from diverse sources to produce a complete and accurate view of the state of the ATM system [R76];

Explanatory text: The originator of information is the ATM community member at the first point of entry where the information can be acquired. To ensure that the information is properly accredited and a quality assurance framework is in place, the responsibility for timely acquisition of information meeting quality parameters must rest with the ATM community member closest to the information event.

The intention is that there will be tracking and quality assurance mechanisms that will ensure the integrity of information through transfer as well as through developing compliance mechanisms for information quality standards.

- h) support a reduction in transactional friction for transmission of information across systems [R78];

Explanatory text: Information management systems will be capable of collecting, storing and aggregating vast amounts of information from, and for use by, ATM community members. It will be necessary to ensure that information needs are legitimate and validated to allow for transparent access to information without being compromised by confidentiality and proprietary interests. Any restrictions on information access should be identified and mechanisms developed and employed for resolution based on balancing access against the legitimate needs of users.

- i) assemble the best possible integrated picture of the historical, real-time and planned or foreseen future state of the ATM system situation and make relevant quality-assured and accredited information available to the ATM system [R123];
- j) ensure that the airspace user makes relevant operational information available to the ATM system, [R07];
- k) use relevant airspace user operational information to optimize flight operations management [R08];
- l) use relevant data to dynamically optimize 4-D trajectory planning and operation [R09];

Explanatory text: The global exchange of information (from individual aircraft performance to ATM system resources) will allow full use of 4-D trajectory management/operation. The 4-D trajectory management optimization may be a function of either ground or air systems or both.

- m) provide the status of ATM system resources [R13];

Explanatory text: The ATM system will monitor the status/availability of all resources within the system and make them readily available, within security constraints, so that entities, operators or agents may use the information to their best advantage in support of their operational objective. For example, based on ATM system resource reports, an operator whose objective is to perform photographic land surveys, is able to amend its work schedule in response to changes in the availability of specific airspace or navaids necessary for the mission. (Since the activity is linked to the physical surface, the option of negotiating another route to avoid the resource limitation is not available, but the operator's work plan, under its control, is amended at the operator's discretion. That is, the activity day/date is amended.)

- n) make available, to the ATM system, flight parameters and aircraft performance characteristics [R31];
- o) establish standards for meteorological model accuracy and resolution and agree on performance requirements [R157];

- p) provide timely access to all relevant meteorological information [R164]; and

Explanatory text: It is expected that within the constraints of authorized access, the ATM community will be permitted to obtain the information required for the discharge of responsibilities. For example, it is expected that historical meteorological data will be available for strategic planning, pre-planning, and tactical planning.

- q) utilize meteorological data, and information derived from it, to assist in analysis and evaluation of agreed environmental performance targets [R127].

Explanatory text: It is expected that increasingly more accurate and timely meteorological and climatological information and analysis material will be available to the ATM community. This information will be increasingly integrated strategically with historical aircraft performance and other data, and tactically with meteorological data from onboard sensors and “downlinked” actual aircraft performance parameters and other data. The enhanced information will allow appropriate members of the ATM community to:

- predict environmentally optimum trajectories which, when integrated with other operational factors, will allow generation of ATM system optimum trajectories (this includes use of dynamic wake vortex spacing), including monitoring of execution;
- facilitate operations of aircraft along environmentally optimum trajectories;
- allow the establishment of pragmatic environmental performance targets; and
- more accurately measure and report the effect of air operations on the environment.

2.2.2 Collaboration

To meet the expectations for the ATM system regarding collaboration, the ATM system shall:

- a) ensure that ATM system design, development, implementation and operation are determined by collaborative decision making, system safety and system-wide business cases [R101];
- b) ensure that decisions affecting the evolution of the ATM system are made in consultation with all affected ATM community members [R163];
- c) ensure that the airspace user community is able to participate in collaborative decision making [R10];
- d) ensure mutual exchange of relevant and timely data:
 - i) for the benefit of situational awareness;
 - ii) for conflict-free trajectory management; and
 - iii) to allow collaborative decision making concerning consequences of airspace user system design changes [R11]; and

Explanatory text: Increased data sharing between all members of the ATM community will enhance both situational awareness and conflict management. This means that both airspace users and service providers should be able to develop their situational awareness and conflict management tools making full use of appropriate exchange of data. The intention is to make available, to each ATM system user, comprehensive information to support situational awareness and subsequent decisions based on the user’s location in real time.

- e) employ collaborative decision making to reconcile differences between information needs and the availability of, or access to, information [R77].

Explanatory text: It is essential that the information needed by an ATM community member to fulfil an ATM system function is acquired and disseminated for use by that member. It is intended that individual ATM community members will be able to access the information relevant to their specific needs.

2.3 SYSTEM DESIGN AND ENGINEERING

Consistent and coherent system design and engineering is critical to achieving the performance expectations; the ATM system shall:

- a) be based on common global standards and procedures [R50];
- b) be based on elements that ensure global interoperability [R51];

Explanatory text: The expectation is that ICAO will, in a timely manner, be responsible for the adoption/approval of SARPs and PANS in order for the ATM community to progress the evolution of the ATM system.

- c) utilize systems standardized at a functional level [R206]; and
- d) incorporate interoperability during the design of any changes to the ATM system [R207].

2.3.1 Interoperability, seamlessness and infrastructure

To meet the expectations for the ATM system regarding interoperability, seamlessness and infrastructure, the ATM system shall:

- a) establish a global ATM system vocabulary with a well-defined form (syntax) and meaning (semantics) such that each participating entity in the exchange will be able to interpret the information provided in precisely the same way. In this context, information is considered to encompass voice, text, data and imagery elements [R170];

Explanatory text: Interoperable and seamless global ATM system capability cannot be achieved through application of agreed technical requirements alone; it must also be addressed at the institutional and operational levels.

- b) ensure that, in any transaction, each participating ATM community entity uses the global ATM system vocabulary to describe the ATM services that it provides within its area of service provision [R171];
- c) ensure that each participating ATM community entity provides a means for other participating entities to identify and access its services. The means for determining and accessing service shall be based on a common description framework and associated method(s) that the participating entities can use to facilitate the introduction and transition to new technologies [R172];
- d) ensure that the communication media/protocols used to support interoperability — both in determining and providing services across discontinuities — are agreed in conformance with internationally approved, open and non-proprietary standards, i.e. the specification of the media/protocols and their operational performance must be freely available [R173];

Explanatory text: The specific call for use of open, non-proprietary standards will apply to their use regionally or globally. It is not intended to preclude the notion of agreements between a limited number of service providers that may rely on “closed” or proprietary mechanisms separate from the global standards — provided that they impose no cost or other burden on those not party to the specific agreement.

- e) ensure the selection and adoption and, where necessary, the development of interoperability standards and related materials that enable mutual exchange of relevant and timely data [R208]; and

Explanatory text: The expectation is that the ATM community will be responsible for selection and, where necessary, the development of candidate global standards (and related material) on interoperability for the ATM system.

However, given that the ATM community will rely on these standards (and related material) to progress the evolution of the ATM system and, given that the proliferation of standards (and related material) may impact performance, the expectation is:

- *that only some of the candidate standards (and related material) will become ICAO Standards (and related material such as Recommended Practices, procedures and guidance material); and*
- *that the selection process will be based on ICAO processes.*

- f) provide a collaboratively agreed minimum notice period in which a State or region intends to change or withdraw the existing infrastructure and/or services [R126].

Explanatory text: Continuity of service provision requires strategic agreement on facilities and services. Significant investments are made to achieve continuity — they must be protected.

2.3.2 Human design and automation

To meet the expectations for the ATM system regarding human design and automation, the ATM system shall:

- a) give due consideration to the interaction of humans and technology, for example, the “human-machine interface” in the design of the ATM system or its parts [R136a)];
- b) demonstrate this consideration in the safety analysis accompanying the system design [R136b)];
- c) guard against the potential to create a safety hazard by information overload [R137]; and

Explanatory text: The human is an essential part of the ATM system. Both in the aircraft and on the ground, the role of the human is to manage the system and supervise control functions. It is intended that in the design of the ATM system or its parts, due consideration will be given to factors that affect human performance, human roles and responsibilities, and the potential for errors so that automation shall be seen as supporting areas of human weakness and complementing areas of human strength.

- d) use automation collaboratively where deemed appropriate to achieve the ATM system performance targets [R86].

2.3.3 Spectrum

To meet the expectations for the ATM system regarding spectrum, the ATM system shall:

- a) ensure that in supporting ATM system expectations, the developers of telecommunications systems ensure that harmful interference will neither be caused by, nor received from, other authorized users [R132a)];
- b) establish and maintain frequency and spectrum allocation and management assistance programmes [R132b)]; and
- c) provide frequency and spectrum management assistance to all new and existing programmes to ensure that national and international standards are complied with and that no new items of equipment are introduced that would interfere with existing systems [R133].

Explanatory text: Formal programmes will be established to ensure that frequency and spectrum development activities for new systems, being conducted by States, are compatible with current and projected use by national and international aviation interests. Frequency allocation proposed for new transmitting and receiving equipment at a site should be coordinated to ensure electromagnetic compatibility with existing systems present or planned for that site. Coordination with external (non-aviation) agencies is required to prevent electromagnetic compatibility problems and resolve out-of-band interference problems with other new or existing national or international systems.

2.3.4 Aircraft design

The aircraft is a key element of the ATM system. The aircraft should be totally integrated in the collaborative decision making of the airspace user operation, and its design should allow it to comply with all relevant ATM system requirements. To meet the expectations for the ATM system regarding aircraft design, the ATM system shall:

- a) make the best use of aircraft capabilities [R209];

Explanatory text: ATM system design will be capable of fully exploiting flight deck systems and aircraft design.

- b) ensure that the interrelationship and interdependency of aircraft design and ATM performance are key considerations in aircraft design [R210]; and

Explanatory text: The design of an aircraft to provide maximum efficiency of ATM system operation relates to the performance in specific areas; the notion of design for overall effectiveness relates to the effect of the aircraft across a range of performance areas to enhance total system performance. In this case, there may be tradeoffs between an aircraft's overall effectiveness and its ability to provide maximum efficiency in one particular area.

It is expected that aircraft design will:

- reduce the occurrence and/or effect of wake vortexes;
- take into account environmental considerations such that noise and emissions are reduced;
- enable aerodrome operation without requiring changes to the infrastructure; and
- facilitate cooperation and integration with the ATM system through the flight deck, including avionics and overall aircraft system design.

The design of the ATM system will reflect the business case process described in the OCD. Cost-benefit assessments should consider the effects of the proposed changes at an overall level, and for the typical

main groups of interests, to ensure that the changes proposed are both viable and affordable. ATM system design will be capable of fully exploiting flight deck systems and aircraft design.

- c) ensure that aircraft capabilities will be totally integrated into the collaborative decision-making process of the ATM community and will allow it to comply with all relevant ATM system requirements [R177].

Explanatory text: Flight crews are deeply involved in the ATM system, in addition to traditional aircraft handling. It is intended that flight deck design should enable better integration with the total ATM system.

2.4 ATM SYSTEM COMPONENTS

2.4.1 Airspace organization and management

Airspace organization establishes airspace structures to accommodate the different types of air activity, volume of traffic, and differing levels of service. Airspace management is the process by which airspace options are selected and applied to meet the needs of the ATM community. To meet the expectations of the ATM system, deriving from airspace organization and management, the ATM system shall:

- a) recognize that operation of the ATM system will not compromise the sovereignty of any State [R01];
- b) establish agreements to ensure that sovereignty of airspace is respected without imposing inefficiencies on ATM airspace management [R02];

Explanatory text: ATM system services will be provided supra-State or extra-State, in whole or in part, subject to the agreement of the appropriate authority within the State or States concerned.

- c) define, through collaborative decision making, airspace structures and procedures to accommodate all types of air activity [R04];
- d) utilize the collaborative decision-making process across State boundaries to support homogeneous traffic flows and seamless airspace [R05];

Explanatory text: Airspace should be organized to be simple and easily understandable.

- e) ensure that airspace users are included in all aspects of airspace management via the collaborative decision-making process [R15];
- f) recognize that airspace will be managed on the basis of flexible allocation [R16];
- g) recognize the principles of access and equity in the organization, flexible allocation and use of airspace [R105];
- h) manage airspace dynamically and flexibly based on services demanded [R106];
- i) recognize that any restrictions on airspace availability will be minimized, and none will be permanent [R17];

Explanatory text: All ATM system users will be able to present a safety, business or personal outcome requirement for use of the airspace, increasing information flow and the ability to manage

use of all airspace efficiently and effectively. More efficient and transparent ATM system user objectives will be achieved and made known to the system. The principles of access and equity will be realized in a practical way.

- j) adapt airspace organizational boundaries, divisions and categories based on traffic patterns, changing situations and unplanned requirements, supporting efficient operation of the other ATM services while not being constrained by national or facility boundaries [R107];
- k) allocate airspace volumes that enable safe and efficient trajectory allocation and modification, from strategic to tactical [R03];
- l) manage all airspace and, where necessary, be responsible for amending priorities relating to access and equity that may have been established for particular volumes of airspace. Where such authority is exercised, it shall be subject to rules or procedures established through collaborative decision making [R18];

Explanatory text: It is accepted that certain volumes of airspace may be established to meet certain ATM system user expectations, including security (or national interest). This may be deemed the primary use. Where that primary use is not operationally required, the ATM system should provide access to those members of the ATM community who were subject to access restriction, until prioritization is required again. It should also be accepted that there will be situations in which priority access is required in response to abnormal operations, such as emergency situations or deviations around severe weather.

- m) accommodate mixed equipage without unduly constraining the primary use of a given volume of airspace [R19];
- n) determine, through collaborative decision making, the level of service for a particular airspace volume, whether determined strategically, pre-tactically or tactically [R20];
- o) facilitate, as feasible, provision for tactical or pre-tactical approval of preferred routing or re-routing in those areas where approvals are required for civil or State aircraft to operate over, into or from a particular State [R99];

Explanatory text: Currently, many States require significant advance notice before approving overflight; this is particularly true of State aircraft operations. The information-rich environment of 2025 should render such restrictions redundant. Additionally, the ATM system should enable enhanced civil and military cooperation and coordination regarding airspace usage and ATM services. Furthermore, it should support models where the military ATM services are already integrated into the civil ATM services.

- p) operate on the principle that all airspace is the concern of the ATM system and is a usable resource, and any restriction on the use of any airspace will be considered transitory [R108]; and
- q) operate on the principle that all airspace will be managed and all related activity within airspace will be known to the ATM system to the degree necessary to meet performance expectations [R109].

2.4.2 Aerodrome operations

As an integral part of the ATM system, the aerodrome must provide the needed ground infrastructure including, *inter alia*, lighting, taxiways, runways and precise surface movement guidance to improve safety and to maximize aerodrome capacity in all meteorological conditions. The ATM system will enable the efficient use of the capacity of the aerodrome airside infrastructure. To meet the performance expectations of the ATM system stemming from aerodrome operations, the ATM system shall:

- a) provide a facility and/or procedure, as required, to monitor or manage aircraft operations safely and expeditiously within the confines of the aerodrome and its immediate surroundings [R21];

Explanatory text: In considering the need for a service facility, such as a control tower, careful thought should be given to the volume and complexity of traffic. Where required, such facilities should enable direct or individual visual monitoring and/or control. However, increasing needs for (vertically) higher visual control rooms to enable direct sighting requirements may lead to alternative methods of surveillance or control. Cost efficiency of services may also become an influencing factor. This may lead to implementation of procedures, such as pilot autonomy (e.g. self-separation) rather than establishment or refurbishment of a facility.

- b) provide collaboratively agreed aerodrome capacity [R23];

Explanatory text: At all aerodromes, a common, collaboratively agreed-to target level of safety will be established, which is subsequently non-negotiable by an individual party. It must be accepted that though performance may be measured on an individual basis, the relationship between each aerodrome will result, by necessity, in a compromise. Performance criteria may be established at the regional or local level; however, consideration should be given to the impact of aerodrome performance on the ATM system as a whole. The freedom of the performance level to termination per aerodrome may be constrained by the performance level of the overall ATM system. It may be easier to consider aerodrome operations within an “en-route to en-route”² perspective in determining their role within the ATM system.

It is intended that sufficient airside infrastructure be provided so as to optimize the efficiency of the ATM system and provide predictability.

- c) ensure, through collaborative decision making, that the most effective means of surface management are employed to respond to demand [R24];
- d) ensure that the position and intent of all aircraft and vehicles operating on the movement area are precisely determined [R25];

Explanatory text: Precise surface movement guidance will be required in all conditions. This may not necessarily be met by high-level technology but should be appropriate to the operations (traffic volume, complexity of traffic movements, traffic mix and so on). Information on the position, to an appropriate level of accuracy, and intent of all aircraft and vehicles operating on the ground will be available to the appropriate ATM community members. Any activities that take place on the movement area can have a direct influence on the ATM system.

- e) ensure that the aerodrome community, including emergency and essential services, provides and receives relevant information in order for dynamic, tactical and strategic decisions to be made [R26];
- f) ensure that flight parameters and aircraft performance characteristics are available to the ATM system [R27];

Explanatory text: As is the case across the whole ATM system, in relation to aerodrome operations, the availability and exchange of information will facilitate management by trajectory. It is expected that the collaborative exchange process and respective facilities will allow for efficient management of air traffic flow through use, on a system-wide basis, of information on air traffic flow, weather and assets. This process will also allow, for example, allocation of entry/exit times for aerodromes and subsequent dynamic changes to mitigate any imbalance.

2. Refer to the discussion of “En-route to En-route” in Appendix C.

- g) determine, through collaborative decision making, suitable aerodrome facilities to enable efficient maintenance of capacity in all weather conditions [R84];
- h) support the same throughput in all weather conditions at aerodromes where benefits can be demonstrated [R29];

Explanatory text: Planned ATM system optimum throughput should be maintained through meteorological conditions that do not present safety limitations and have been agreed by the affected ATM community members.

- i) consider environmental issues in the design, development and operation of the aerodrome [R30];

Explanatory text: Through the ATM system, aerodrome operations should contribute to the protection of the environment by considering all environmental impact areas to the extent that safety is not compromised.

It is expected that in the design of terminal area procedures, responsible authorities will work closely with local agencies to mitigate, to the extent possible, the effect of aviation on communities located within the terminal area of an airport. In so doing, all parties should strike an appropriate balance between the need to mitigate the effects of aviation on the environment, and the significant economic benefit to States of promoting a healthy aviation industry.

It is expected that airspace users, in determining and executing user-preferred trajectories, will incorporate requirements to ameliorate unnecessary gaseous emissions. The ATM system should recognize and accommodate such trajectories wherever practicable to reduce the environmental impact.

Meteorological information, both current and forecast, will be an important contributing factor in managing environmental issues. It is expected that while aerodrome operations will not be responsible for determining environmental constraints, they will comply with local and national requirements.

As one of the sources of environmental pollution, aerodrome layouts and operations will, through collaboration, alleviate environmental concerns. (For example, reduced holding will assist aerodromes in complying with emission controls as will reduced taxiing times.)

- j) establish, through strategic, pre-tactical and tactical collaborative decision making, processes for facilitating throughput of passengers and/or cargo and freight at airports, which will allow agreed performance parameters to be met by the ATM system partners [R100];

Explanatory text: It is expected that landside operations will become an integral part of this process. Although not directly part of the ATM system, landside operations will have an impact on aerodrome operations, and a downstream effect on other parts of the ATM system. Data on such areas as modal transportation systems, customs, security, baggage handling, fuel supply, and so on, shared through collaborative information exchange, will optimize operations.

Real-time data, together with system trends and forecasts, fused with a range of automated decision support or decision-making tools, will enable optimization of services. A common understanding of the needs and capabilities of all parties will instigate a better response to a given situation. Gate management will benefit from the ability to tactically and collaboratively modify sequences to optimize aerodrome operations. It is expected that those ATM community members interfacing with landside operations will manage/mitigate the effects of landside operations so that impacts on the ATM system are minimized or eliminated.

- k) ensure appropriate levels of security, recognizing that security is most visible in the aerodrome environment and that the requirements associated with security may vary from time to time and according to location [R168];

Explanatory text: It is expected that, increasingly, law enforcement agencies will require flight identification and trajectory data as well as general information concerning traffic at aerodromes. Data exchange will be subject to agreement between interested parties and may be influenced by commercial and regulatory factors. It is noted that, in some instances, access to certain areas may be restricted to those willing to provide a minimum level of information (e.g. specific aircraft flying into certain aerodromes and airspace).

- l) establish procedures reducing any need for departing or arriving aircraft to spend ground time holding for services with engines operating [R178]; and
- m) establish procedures to accommodate arrivals without aircraft having to enter airborne holds for aerodrome service accommodation as a routine [R179].

2.4.3 Demand and capacity balancing

2.4.3.1 Demand and capacity balancing will strategically evaluate system-wide traffic flows and aerodrome capacities to allow 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 use of information on system-wide air traffic flows, weather and assets.

2.4.3.2 To increase service predictability, maximize capacity utilization and achieve collaboratively-agreed performance targets for the ATM system in those areas to which the ATM system components of demand and capacity balancing contribute, the ATM system shall:

In relation to the provision of information:

- a) provide timely and accurate information regarding projected demand and capacity levels [R32];
- b) facilitate, as appropriate and on request, the conduct of capacity and demand projections and make the results of that analysis available to the ATM service delivery management function [R160]; and
- c) facilitate provision of ATM system demand and capacity projections to relevant ATM community members for up to an agreed/specified time in advance [R159].

Explanatory text: In relation to the provision of information for demand and capacity balancing, the ATM system will be capable of projecting the current and future capacity of, and demand on, specified operating sectors or airspace volumes or routes/route segments using all available data and information. This includes the actual and forecast meteorological conditions, navigation equipment operational status, aerodrome operational status, runway configuration, and aircraft performance characteristics.

The ATM system will also monitor and use information pertinent to demand projections, including stored flight plan information, filed flight plan information, aerodrome operational status, historic demand profiles, scheduled special events and military operations.

In relation to access to information:

- d) provide timely access to all relevant information, including weather information [R33]; and
- e) provide all users the same level of access to collaborative decision making concerning ATM resources, realizing the diverse need to balance the expectations and interests of all members of the ATM community in achieving equity and access [R34].

In relation to the use of information:

- f) facilitate collaboration on projections and responses regarding demand, capacity, predictability, capacity utilization and cost-effectiveness [R35];
- g) utilize historical and forecast weather information, including seasonal patterns and major weather phenomena [R36a]);
- h) use information on changes in infrastructure status to increase predictability and maximize capacity utilization to meet performance targets [R36b)];
- i) ensure collaboration on post-event analysis to support strategic planning [R36c)];
- j) utilize projected traffic demand and planned trajectories [R36d)];
- k) accommodate revisions to trajectory requests and resource status [R36e)];
- l) ensure collaboration on projections and responses [R36f)];
- m) facilitate collaboration on trajectory changes and traffic demands [R36g)]; and
- n) consider current and predicted airspace conditions and projected demand as well as past performance [R114].

Explanatory text: In relation to use of information for demand and capacity balancing, it is intended that within the constraints of authorized access, the appropriate ATM community members will be permitted to obtain as much of the information required to perform their responsibilities.

For example, it is intended that historical meteorological data will be available for strategic planning of long-term capacity and demand balancing. This will be coupled with predicted and current meteorological information to facilitate determination of the level of demand and effect on capacity.

It is intended that tactical information from on-board sensors will be integrated into the data stream. Where there is a conflict regarding access to information, it is expected to be resolved within the service delivery management function.

It is intended that strategic evaluation of available information — including system-wide traffic flows, aerodrome capacities and active runways, meteorological information and flow management information — will facilitate determination by airspace users of when, where and how they operate. It is intended that collaborative use of common data, information and decision support tools will:

- ensure the most efficient use of all available and potential resources;
- provide the greatest possible access to aerodrome services;
- provide equitable access for all airspace users;
- accommodate user preferences; and
- ensure that demand on an aerodrome and other services will not exceed their capacity.

In relation to provision of service:

- o) provide a capability to meter traffic to achieve a balance between traffic demand and the capacity of the ATM system [R145];

- p) establish a collaborative process to allow for efficient management of the air traffic flow through use of information on system-wide air traffic flow, weather and assets [R112];
- q) utilize system-wide balancing techniques to collaboratively resolve local demand and capacity balancing problems [R113]; and

Explanatory text: In relation to providing services for demand and capacity balancing, while principles of access and equity will apply throughout the ATM system, it is intended that operators of an aircraft not compatible with the majority of users in a given operational scenario will not be granted the right of equity and access without due consideration of the impact on the performance of the ATM system as a whole. It is intended that arbitration of access and equity issues, at least at a tactical level, will be conducted through the service delivery management function.

It is intended that the demand and capacity balancing function within the ATM system will support the service delivery management function in conducting strategic planning [e.g. airspace, optimal staffing, and routing]; pre-tactical planning [e.g. adjust staffing, forecast initiatives (fine-tune routing, etc.), airspace user schedule adjustments]; and tactical planning [e.g. flow initiatives (rerouting, sequencing and spacing of aircraft, etc.) and airspace user schedule adjustments], all based on forecast and known demand and capacity and analysis of historical performance data.

It is intended that with the increased reliability of, and access to, information, potential saturation of airspace or aerodromes will be predicted sufficiently in advance to ameliorate — or negate — the impact of that saturation event. It is intended that the ATM system will enable a capability to determine actual or potential saturation of any selected airspace and/or aerodromes. In accordance with other ATM system requirements, it is intended that any such information will be made available to relevant ATM community members.

- r) provide the capability to evaluate the effectiveness of flow restrictions implemented in the ATM system. Effectiveness criteria shall include overall system performance measures [R161].

Explanatory text: The ATM system will include the capability to monitor its performance and effectiveness in meeting the range of performance targets. This applies particularly to demand and capacity balancing, where there is a high degree of criticality to overall ATM system performance and where decisions — strategic and tactical — are made largely on the basis of historical data and observed performance.

2.4.4 Traffic synchronization

Traffic synchronization refers to the tactical establishment and maintenance of a safe, orderly and efficient flow of air traffic. To meet the performance expectations, the ATM system shall:

- a) provide for an orderly flow of traffic from gate to gate by dynamically renegotiating the 4-D trajectory contract [R80];
- b) apply traffic synchronization for the purpose of maximizing the throughput of a particular ATM environment in the most effective and efficient manner [R169];

Explanatory text: It is possible to achieve high throughput inefficiently. It is expected that traffic synchronization will be applied to achieve high throughput and high efficiency, whether or not 4-D trajectories are being applied.

- c) maximize, through the use of traffic synchronization, throughput to meet ATM performance requirements [R83];

- d) manage 4-D trajectory contracts to achieve safe and efficient trajectories [R82];

Explanatory text: Agreed 4-D trajectory contracts will be dynamically updated and communicated to the ATM community. Safety and efficiency in collaboration are key to the changes regardless of whether the service is provided from the air or the ground. Negotiation and control will make use of the best available automated tools for communication, analysis and action.

It is expected that through dynamic renegotiation of agreed 4-D trajectory contracts — and subject to the appropriate business case to ensure cost-effectiveness — the ATM system will not experience “chokepoints.” Potential ATM system chokepoints should be increasingly more predictable as 4-D trajectories become available together with automated tools for mitigation. The balancing of traffic density with variations in demand should, where appropriate, be based on the 4-D trajectory contracts received from demand and capacity management.

It is expected that automation both in the air and on the ground will be used fully in order to create an efficient and safe flow of traffic for all phases of flight. The ATM system, through full use of available automation, will be able to analyse and accurately predict future situations in order to achieve the best performance.

Requirements for the airspace user to adhere to the agreed trajectory, within agreed tolerances, will remove much of the uncertainty regarding the future positions of aircraft.

- e) support the discharge of traffic synchronization by both airborne and ground-based systems [R85];
- f) use 4-D trajectory control and/or flight deck delegation for aircraft spacing [R182];
- g) utilize the 4-D trajectory for traffic synchronization applications to meet the ATM system performance targets unless, under certain conditions, other means are determined to be more effective [R87];

Explanatory text: It is expected that the separation mode, including wake vortex separation minima will determine the minimum possible aircraft spacing. It is expected that flight parameters, as part of the 4-D trajectories management, will be available to the ATM system to dynamically allow for spacing and sequencing of arriving as well as departing aircraft. It is expected that as flight parameters are available on airborne systems, they will be used continuously and dynamically, both between aircraft and between aircraft and ground, to maximize utilization of the best information available. This will constitute/facilitate a safer and more efficient use of available airspace and will increase aerodrome throughput.

It is expected that flight plans will be replaced by 4-D trajectory contracts for all phases of flight. 4-D trajectory contracts will constitute a prerequisite for dynamic control of aircraft and vehicles. Negotiations will take place dynamically because total awareness will be available to the complete ATM community. Agreed 4-D trajectories will increase predictability as well as reduce the need for current traditional path-stretching methodologies.

It is expected that spacing between aircraft will be done through the use of 4-D trajectories, which will be updated and interacted upon collaboratively. The 4-D trajectories will be provided as 4-D trajectory contracts and will be modified and acted upon dynamically and according to at least the criteria defined by conflict management to create a safe and orderly flow of traffic.

It is expected that when traffic density becomes a critical factor affecting performance — whether of an aerodrome or an airspace — application of traffic synchronization will be used and tailored for best performance. The decision to apply traffic synchronization in this case may be taken in advance of flights. In any case, it will be closely coordinated with the demand and capacity balancing function to ensure timely and accurate application of traffic synchronization.

- h) ensure that traffic synchronization throughput actions are matched by aerodrome low visibility throughput capacity where this is determined to be cost-effective by the appropriate business case³ [R92];

Explanatory text: It is expected that traffic synchronization will be applied to achieve high throughput and high efficiency across the entire ATM system. This will include working collaboratively with both aerodrome operations and airport landside operations to ensure that ground throughput does not become an obstacle to overall ATM system efficiency.

- i) recognize that traffic synchronization encompasses both the ground and the airborne part of the ATM system and constitutes a flexible mechanism for capacity management [R115]; and

Explanatory text: It is expected that traffic synchronization will contribute to optimized aerodrome operations performance. This will be done through increased awareness and predictability for the ATM community as well as through fulfilment of collaboratively agreed actions leading to achievement of best performance.

- j) manage surface, departure, and arrival and en-route flow of traffic dynamically to optimize traffic flow or throughput [R211].

2.4.5 Airspace user operations

The ATM system is primarily established to service the needs of the airspace user community. Increasingly, the capabilities of the user community are such that they participate as active components of the system. ATM system performance is directly influenced by the performance of the airspace user. To meet the performance expectations of the ATM system stemming from airspace user operations, the ATM system shall:

- a) recognize and exploit airspace user capabilities to generate, negotiate and adhere to user-preferred 4-D trajectories [R44];
- b) consider the trajectory of a vehicle during all phases of flight and manage 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 [R212];
- c) provide airspace users, consistent with available ATM system resources, the capability to fly dynamic user-preferred 4-D trajectories [R43];

Explanatory text: It is expected that user-preferred trajectories will provide the most efficient flight operations and that airspace users will provide these trajectories to the ATM system. These trajectories should be the key/core element of the (shared) information management. The expectation is that the global exchange of information (from individual aircraft performance up to ATM resources) should allow full use of 4-D trajectory management/operation and that the 4-D trajectory management optimization could be a function of either the ground or the air or both.

- d) provide, through its evolution, incentives to upgrade to new capabilities [R48];
- e) provide benefits commensurate with the level of aircraft capabilities or performance [R49];

Explanatory text: It is expected that:

3. Refer to Appendix D.

- *operational benefits and incentives will accelerate the evolution of the ATM system;*
- *incentives will ensure consistent and interoperable evolution of the ATM system; and*
- *the degree of benefits and incentives will be different depending on the type of users.*

It is further expected that:

- *a level of ATM system benefits will be defined in accordance with a level of aircraft capabilities;*
 - *ICAO will develop global Standards for new ATM systems in a timely manner;*
 - *States, recognizing global Standards, will file minimal differences; and*
 - *even during the transition phase, global interoperability will be ensured/managed through benefits commensurate with aircraft capabilities.*
- f) utilize relevant airspace user operational information to meet performance targets [R54];
- g) operate on the basis that airspace users will make available the relevant operational information to the ATM system and vice versa [R53];
- h) operate on the basis that airspace users will provide information on individual aircraft performance [R55];
- i) operate on the basis that airspace users will provide information on the individual operating environment as experienced (real time) [R56];

Explanatory text: It is expected that the ATM system will provide the necessary information for mission planning and coordination, and that mission planning will first interact with airspace organization and/or aerodrome operations for long-term planning and then with airspace management and demand and capacity balancing.

- j) operate on the basis that airspace users will establish and execute operational control of their missions [R59];
- k) accommodate operational control activity [R60]; and

Explanatory text: It is expected that operational control, where utilized, will be exercised over individual missions from initiation to termination. The division between operational control and the flight authority's (captain's or commander's) responsibility for the safety of the flight mission is considered to be a key contributor to the safe operation of the flight.

- l) allow airspace users to fly user-preferred trajectories that are consistent with the applicable airspace management requirements and aircraft capabilities [R116].

2.4.6 Conflict management

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

2.4.6.2 Conflict management will consist of three layers:

- a) strategic conflict management;
- b) separation provision; and
- c) collision avoidance.

2.4.6.3 To meet the performance expectations of the ATM system stemming from conflict management, the ATM system shall:

- a) implement the conflict management function [R61];
- b) define the predetermined separator prior to commencement of separation provision; however, the role of separator may be delegated [R119];
- c) provide rules and means to delegate the role of separator [R214];

Explanatory text: When the role of separator is delegated then the conditions for both start and end of the delegation shall be defined in advance of the delegation. Changes of delegation shall be by agreement.

- d) determine the separator for each renegotiated 4-D trajectory [R81];
- e) provide separation provision service when required by safety or ATM system design [R215];
- f) designate the airspace user as the predetermined separator, unless safety or ATM system design requires a separation provision service [R120];
- g) define separation modes for separation from all hazards, including weather, applicable to all airspace and movement areas [R213];

Explanatory text: The selection of separation minima within ATM system performance constraints seeks to balance the need for appropriate levels of safety performance with other performance expectations, including cost-effectiveness, capacity and efficiency. While it may be possible, for example, to select small (distance/time) separation minima to be applied in a particular operational area, the requirements for supporting navigation, surveillance, communications, and intervention capability performance may be prohibitively expensive, or they may not permit the expected capacity enhancements (because of communication volume limitations, etc.). The choice of appropriate separation minima and supporting infrastructure would be determined through collaborative decision making.

- h) select the applicable separation modes and separation minima for conflict management that best meet the ATM system performance targets [R62];
- i) support strategic, pre-tactical and tactical conflict management. The selection of the type of conflict management shall be based on meeting ATM system performance targets, both before and after departure [R65];
- j) apply tactical conflict management when strategic conflict management cannot be used efficiently [R66];
- k) apply separation provision only when strategic conflict management cannot be used effectively [R118];
- l) limit, to an acceptable level of safety, the risk of collision between aircraft and hazards [R117]; and

- m) ensure that collision avoidance systems activate when the separation mode has been compromised [R216].

Explanatory text: *The risk of collision is maintained at an acceptable level of safety by selecting and applying appropriately defined separation minima (displacements between an aircraft and a hazard). It is intended that the “acceptable” level of safety will be determined from the perception of safety needs by society and the international community, related to the trust required from the ATM system. It is intended that the target level of safety will be based on risk assessment and acceptance criteria and be equal to or better than the “acceptable” level of safety. It is intended that the collision avoidance function not be included in determining the calculated level of safety required for separation provision, although it constitutes the third layer of conflict management and, hence, part of ATM safety management.*

2.4.7 ATM service delivery management

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 balances and consolidates 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 for delivering a balance of decisions. To meet the performance expectations of the ATM system stemming from service delivery management, the ATM system shall:

- a) optimize system-level performance as its highest priority with individual component performance subject to that prioritization [R67];
- b) provide services predicated on management by trajectory and monitor compliance with the agreed trajectory [R68];
- c) define the predetermined separation responsibility [R06];

Explanatory text: *System-wide optimization is a high priority and individual component optimizations operate within the constraints of that priority. The hierarchy of decision making is consistent with these principles. Every decision has an identified responsible party.*

- d) operate on the basis that the airspace user will provide flight and aircraft intent to the ATM system for use in planning and managing 4-D trajectories [R71];
- e) approve execution of 4-D trajectory agreements through issuance of clearances [R72];
- f) monitor and alert when the clearance is inconsistent with the agreement [R73];
- g) monitor and alert when indications are that an aircraft will not be in conformance/compliance with the agreement [R183];

Explanatory text: *Flight intent forms the basis for an ATM system agreement, and changes to the flight intent represent a request for modifications to the agreement. Aircraft intent forms the basis for ATM system confirmation of compliance with the agreement. The allowable variation from the agreed threshold is locally adaptable. Generating an agreement does not imply authority to execute. Initiating the agreement or any portion thereof requires a clearance.*

Clearances may not represent the entire agreement; the system shall alert the appropriate party when this is the case. The intent is to preclude an inadvertent entry into holding or inability to make the next trajectory point due to unintentional failure to provide follow-on clearance. The greater flexibility

inherent in management by trajectory requires automated monitoring of adherence to and variance from the agreed trajectory. All ATM data will be available for accessing and use. The ATM system will automatically monitor, alert and develop responses.

- h) utilize flight trajectory, flight intent and individual aircraft performance characteristics in providing ATM services [R98];

Explanatory text: It is expected that the 4-D trajectory will be globally shared and used by the ATM community in all aspects of its operations. The requirement recognizes the difference between the tolerances associated with the 4-D contracts and what may be more stringent performance capabilities of the individual aircraft. For example, aircraft providing the ATM system with knowledge of their very accurate performance capabilities would, as a result, provide the ATM system opportunity to identify conformance/compliance irregularities that could be used in providing such services as conflict management, security notification/response, and so on.

- i) operate on the basis that all operations are “known to the ATM system” [R125];

Explanatory text: While aircraft may not be subject to any particular service, their participation in the ATM system must be announced either strategically, or pre-tactically by notification of intent, or tactically by immediate notification of intent or operation of identification devices or by operation in predetermined areas. As an example, an aircraft classified in 2000 as a VFR aircraft operating in Class G airspace will be able to operate with the same degree of freedom in the future ATM system, either by notifying intent to operate in a particular way, by carriage and operation of an identification device such as a transponder, or by operating in predesignated airspace, such as the equivalent of Class G.

- j) predict potential saturation of airspace or aerodromes in advance and to a level of accuracy to meet ATM system performance objectives [R143];

Explanatory text: It is expected that the ATM system will be able to determine actual or potential saturation of any selected airspace and/or aerodromes. It is intended that information will be generated that will summarize the problems regarding saturated airspace. If airspace or aerodromes are or will be saturated, the capacity management function shall have the capability to allocate available airspace or aerodrome capacity, determine flight restrictions for specific aircraft and communicate these restrictions and alternate courses of action to users.

- k) provide a capability to evaluate the effectiveness of flow restrictions implemented in the ATM system. Effectiveness criteria shall include overall system performance measures [R146];

Explanatory text: It is expected that the ATM system will provide recommendations for future runway selection based on forecast meteorological conditions, traffic and other conditions that influence the best system solution.

- l) establish an on-request basis for ATM service delivery [R121];

- m) manage distribution of responsibilities for the various services and their seamless performance, including designation of the predetermined separator for separation provision [R122];

Explanatory text: Where ATM system technological solutions and infrastructure are provided across a region or globally by one or more States or organizations, long-term use and operational arrangements shall be established, via the collaborative decision-making process, with the affected ATM community members on behalf of, or for the benefit of, multiple users, States and/or organizations.

- n) work to reduce voice communications as far as is practicable in delivery of ATM services [R148];

Explanatory text: Clarification of the strategic provision of service (i.e. publication of rules for a specific airspace; the publication constitutes the communication). This should apply equally for navigation, surveillance and airspace. Depending on the phase of flight and the requirements associated with any separation mode being applied at the time, provision shall be available for direct or indirect voice or data link communication between the aircraft and the ground air traffic management authority and vice versa. Where communication performance requirements are established, they shall be determined on the basis of the urgency of the communication and whether or not the proposed transmissions are related to command and control-type (i.e. intervention capability) communication. Communications media consist of voice communication (direct or indirect), data link communication, or other means, including visual, aural or sensory signals, to provide or exchange information, data or alert or acknowledgment messages. The media or combination of media to be used for a particular application or function shall be determined from the appropriate concept of use in a region or State. However, in all cases, the selection of communications media shall be based on the principle of global seamlessness and harmonization. Where seamlessness cannot be achieved for technical or cost-effective reasons, communications media must be interoperable.

- o) be based on self-contained navigation supported primarily by on-board and/or space-based systems, as far as is practicable [R149];

Explanatory text: Precision navigation guidance within terminal areas, on final approach, on the ground and/or in the initial departure phase may be provided by dependent or independent self-contained on-board navigation systems or independent ground-based systems. Depending on the phase of flight and requirements associated with any separation mode or minima being applied at the time, navigation performance requirements may be established. These may be based on predicted and/or anticipated performance (contained navigation performance) or actual and/or observed performance (actual navigation performance).

- p) operate on the basis that services to airspace users will be based on the actual navigation performance of the users at the time of service. Where navigation performance requirements are specified, they will be determined on the basis of the navigation accuracy required in a given volume of airspace and/or through specific procedures to maintain appropriate levels of safety with respect to other hazards [R150];

Explanatory text: It is expected that as is the case with current instrument landing system categorization (Cat I, II, III, etc.), having defined a particular performance expectation for a given volume of airspace, or other delineation, it will be the airspace users who will determine how they achieve the requirement and/or whether they can meet the requirement at the time of operation. In the ILS scenario, it is the meteorological conditions at the time of arrival that dictate the minimum performance requirement, and the airspace user determines if the entire system (aircraft equipage, pilot training, ground systems, etc.) is sufficient for the user to attempt an approach.

- q) demonstrate an increased responsiveness across the spectrum of ATM services to real-time changes in airspace user needs. Furthermore, the ATM system should provide the user with at least one alternative in case of changes imposed by the ATM system [R151];

Explanatory text: It is expected that changes imposed by the ATM system will be defined to include changes of status of individual ATM system elements (e.g. revised status of special use airspace or meteorological conditions).

- r) operate on the basis that where surveillance performance requirements are specified, they will be determined on the basis of the accuracy of position determination (and subsequent display) required in a given volume of airspace and/or specific procedure to maintain appropriate levels of safety with respect to other hazards [R152];

Explanatory text: Depending on the phase of flight and the requirements associated with any separation mode or minima being applied at the time, surveillance requirements and surveillance performance requirements may be established. When specifying these requirements or performance expectations, consideration should be given to the potential inaccuracy of position derived from either dependent or independent surveillance (as a result of the uncertainty of position of the aircraft in the case of dependent surveillance or the system inaccuracies engendered by independent surveillance systems) and to the ability of the various systems to either predict future position or provide intent.

- s) operate on the basis that where there is a conflict between access and equity, allocation of priority to airspace users will be based on the principle of maximizing ATM system performance [R153];

Explanatory text: Existing practices relating to access and equity, particularly the “first come, first served” paradigm, should be amended to reflect the overall intent to improve ATM system performance. This is not intended to prohibit or block access to airspace; it is intended to allow establishment of procedures, through collaborative decision making, that optimize use of runways and/or airspace.

- t) operate on the basis that ATM service delivery will participate in determination of airport capacity and will be aware of the available airport capacity at relevant airports at all times to be able to maximize use of that capacity [R154]; and

Explanatory text: ATM system capacity at and around airports should not act as a constraint on airport scheduling. It is expected that the ATM system will be capable of projecting for specified aerodromes and runways the number of arrivals and departures that can be handled and the number of planned arrivals and departures. The number of arrivals and departures of IFR traffic that can be handled by a specific aerodrome, and the number of planned arrivals and departures of IFR traffic projected in the future at a specific aerodrome or runway, will be provided through effective information management by the ATM system.

It is expected that factors such as runway surface conditions, surface meteorological conditions, winds aloft, local acceptance rate data, and terminal navigation equipment status will be monitored and used to determine actual capacity projections. It is expected that information will be delivered upon request to the level of detail specified by the user.

- u) ensure that appropriate mechanisms are established and maintained to ensure appropriate authority, responsibility and data control of all ATM system information so that the various parties use a coherent set of data [R155].
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Appendix A

LIST OF REQUIREMENTS CROSS-REFERENCED TO THE GLOBAL AIR TRAFFIC MANAGEMENT OPERATIONAL CONCEPT (OCD) (DOC 9854)

ATM requirement number	Requirement	OCD reference
R01	Recognize that operation of the ATM system will not compromise the sovereignty of any State	2.2.2; Appendix A (States)
R02	Establish agreements to ensure that sovereignty of airspace is respected without imposing inefficiencies on ATM airspace management	2.2.2; Appendix A (States)
R03	Allocate airspace volumes that enable safe and efficient trajectory allocation and modification, from strategic to tactical	2.2.2
R04	Define, through collaborative decision making, airspace structures and procedures to accommodate all types of air activity	2.2.5
R05	Utilize the collaborative decision-making process across State boundaries to support homogeneous traffic flows and seamless airspace	2.2.3
R06	Provide a global, common aviation data standard and reference system to allow fusion and conflation and provide comprehensive situational awareness and conflict management	2.1.6 b); 2.6.7 a)
R07	Ensure that the airspace user makes relevant operational information available to the ATM system	2.1.6 c)
R08	Use relevant airspace user operational information to optimize flight operations management	2.6.7 b)
R09	Use relevant data to dynamically optimize 4-D trajectory planning and operation	2.1.6 d)
R10	Ensure that the airspace user community is able to participate in collaborative decision making	2.1.6 e)
R11	Ensure mutual exchange of relevant and timely data: <ul style="list-style-type: none"> — for the benefit of situational awareness; — for conflict-free trajectory management; and — to allow collaborative decision making concerning consequences of airspace user system design changes 	2.1.6 b); 2.6.7 a)

ATM requirement number	Requirement	OCD reference
R12	Establish information exchange protocols and procedures to ensure that appropriate performance can be achieved within the agreed rules	2.1.1; 2.9.1
R13	Provide the status of ATM system resources	2.1.6 d); 2.6.7 c)
R14	Deleted	
R15	Ensure that airspace users are included in all aspects of airspace management via the collaborative decision-making process	2.2.1
R16	Recognize that airspace will be managed on the basis of flexible allocation	2.2.1
R17	Recognize that any restrictions on airspace availability will be minimized, and none will be permanent	2.2.1
R18	Manage all airspace and, where necessary, be responsible for amending priorities relating to access and equity that may have been established for particular volumes of airspace. Where such authority is exercised, it shall be subject to rules or procedures established through collaborative decision making	2.2.9
R19	Accommodate mixed equipage without unduly constraining the primary use of a given volume of airspace	2.2.8
R20	Determine, through collaborative decision making, the level of service for a particular airspace volume, whether determined strategically, pre-tactically or tactically	2.2.6
R21	Provide a facility and/or procedure, as required, to monitor or manage aircraft operations safely and expeditiously within the confines of the aerodrome and its immediate surroundings	2.3.1
R22	Deleted in ATMRPP WG/WHL/2	
R23	Provide collaboratively agreed aerodrome capacity	2.4.2; 2.4.3; 2.4.4; 2.4.5
R24	Ensure, through collaborative decision making, that the most effective means of surface management are employed to respond to demand	2.3.4; 2.3.6
R25	Ensure that the position and intent of all aircraft and vehicles operating on the movement area are precisely determined	2.3.4; 2.3.6
R26	Ensure that the aerodrome community, including emergency and essential services, provides and receives relevant information in order for dynamic, tactical and strategic decisions to be made	2.3.1; 2.3.4; 2.3.7; 2.3.9
R27	Ensure that flight parameters and aircraft performance characteristics are available to the ATM system	2.3.9; 2.5.6 d)
R28	Deleted in review at an ad hoc meeting, Miami, 21 February 2005	

ATM requirement number	Requirement	OCD reference
R29	Support the same throughput in all weather conditions at aerodromes where benefits can be demonstrated	2.3.4 b)
R30	Consider environmental issues in the design, development and operation of the aerodrome	2.3.8
R31	Deleted	
R32	Provide timely and accurate information regarding projected demand and capacity levels	2.4.1
R33	Provide timely access to all relevant information, including weather information	2.4.1
R34	Provide all users the same level of access to collaborative decision making concerning ATM resources, realizing the diverse need to balance the expectations and interests of all members of the ATM community in achieving equity and access	2.4.2
R35	Facilitate collaboration on projections and responses regarding demand, capacity, predictability, capacity utilization and cost-effectiveness	2.4.3 a)
R36	<ul style="list-style-type: none"> a) Utilize historical and forecast weather information, including seasonal patterns and major weather phenomena; b) Use information on changes in infrastructure status to increase predictability and maximize capacity utilization to meet performance targets; c) Ensure collaboration on post-event analysis to support strategic planning; d) Utilize projected traffic demand and planned trajectories; e) Accommodate revisions to trajectory requests and resource status; f) Ensure collaboration on projections and responses; g) Facilitate collaboration on trajectory changes and traffic demands 	2.4.3
R37	Deleted	
R38	Deleted	
R39	Deleted	
R40	Deleted	
R41	Deleted	
R42	Deleted	
R43	Provide airspace users, consistent with available ATM system resources, the capability to fly dynamic user-preferred 4-D trajectories	2.6.11

ATM requirement number	Requirement	OCD reference
R44	Recognize and exploit airspace user capabilities to generate, negotiate and adhere to user-preferred 4-D trajectories	2.6.11
R45	Be designed to accommodate all types of airspace user missions and all types of vehicles and associated characteristics	2.6.2
R46	Deleted	
R47	Deleted	
R48	Provide, through its evolution, incentives to upgrade to new capabilities	2.6.5
R49	Provide benefits commensurate with the level of aircraft capabilities or performance	2.6.5
R50	Be based on common global standards and procedures	2.6.5
R51	Be based on elements that ensure global interoperability	2.6.5
R52	Deleted	
R53	Operate on the basis that airspace users will make available the relevant operational information to the ATM system and vice versa	2.6.7 b)
R54	Utilize relevant airspace user operational information to meet performance targets	2.6.7 b)
R55	Operate on the basis that airspace users will provide information on individual aircraft performance	2.6.7 c)
R56	Operate on the basis that airspace users will provide information on the individual operating environment as experienced (real time)	2.6.7 c)
R57	Deleted	
R58	Deleted	
R59	Operate on the basis that airspace users will establish and execute operational control of their missions	2.6.9
R60	Accommodate operational control activity	2.6.10
R61	Implement the conflict management function	2.7.1
R62	Select the applicable separation modes and separation minima for conflict management that best meet the ATM system performance targets	2.7.2
R63	Deleted	
R64	Deleted	

ATM requirement number	Requirement	OCD reference
R65	Support strategic, pre-tactical and tactical conflict management. The selection of the type of conflict management shall be based on meeting ATM system performance targets, both before and after departure	2.7.11
R66	Apply tactical conflict management when strategic conflict management cannot be used efficiently	2.7.1.3
R67	Optimize system-level performance as its highest priority with individual component performance subject to that prioritization	2.8.1
R68	Provide services predicated on management by trajectory and monitor compliance with the agreed-to trajectory	2.8.2
R69	Deleted	
R70	Implement system-wide information management	2.8.4
R71	Operate on the basis that the airspace user will provide flight and aircraft intent to the ATM system for use in planning and managing 4-D trajectories	2.8.8
R72	Approve execution of 4-D trajectory agreements through issuance of clearances	2.8.11
R73	Monitor and alert when the clearance is inconsistent with the agreement	2.8.11
R74	Provide to the ATM community accredited, quality-assured and timely information meeting the identified standards of performance, including quality of services	2.9.2
R75	Provide information systems that identify the nature of the information in terms of timeframe — historical, current or planned	2.9.3
R76	Be capable of collecting and integrating information from diverse sources to produce a complete and accurate view of the state of the ATM system	2.9.3
R77	Employ collaborative decision making to reconcile differences between information needs and the availability of, or access to, information	2.9.3
R78	Support a reduction in transactional friction for transmission of information across systems	2.9.5
R79	Ensure that a relevant validity period of ATM system information is evident to the user of that information	2.9.7
R80	Provide for an orderly flow of traffic from gate to gate by dynamically renegotiating the 4-D trajectory contract	2.1.5
R81	Determine the separator for each renegotiated 4-D trajectory	2.1.5

ATM requirement number	Requirement	OCD reference
R82	Manage 4-D trajectory contracts to achieve safe and efficient trajectories	2.1.5
R83	Maximize, through the use of traffic synchronization, throughput to meet ATM performance requirements	2.1.5 a)
R84	Determine, through collaborative decision making, suitable aerodrome facilities to enable efficient maintenance of capacity in all weather conditions	2.3.4 b)
R85	Support the discharge of traffic synchronization by both airborne and ground-based systems	2.5.2
R86	Use automation collaboratively where deemed appropriate to achieve the ATM system performance targets	2.5.3
R87	Utilize the 4-D trajectory for traffic synchronization applications to meet the ATM system performance targets unless, under certain conditions, other means are determined to be more effective	2.5.6 b)
R88	Deleted	
R89	Deleted	
R90	Deleted	
R91	Deleted	
R92	Ensure that traffic synchronization throughput actions are matched by aerodrome low visibility throughput capacity where this is determined to be cost-effective by the appropriate business case	2.3.4 b)
R93	Deleted	
R94	Deleted	
R95	Deleted	
R96	Deleted	
R97	<ul style="list-style-type: none"> a) Ensure that performance forms the basis for all ATM system development; b) Ensure that performance targets are defined, regularly reviewed and monitored; c) Establish interchange of global benchmarking performance data as a cornerstone of ATM system management 	1.7; Appendix F
R98	Utilize flight trajectory, flight intent and individual aircraft performance characteristics in providing ATM services	2.8.10

ATM requirement number	Requirement	OCD reference
R99	Facilitate, as feasible, provision for tactical or pre-tactical approval of preferred routing or re-routing in those areas where approvals are required for civil or State aircraft to operate over, into or from a particular State	2.2.3; 2.2.5 a); 2.2.5 b); 2.2.5 c); 2.2.7
R100	Establish, through strategic, pre-tactical and tactical collaborative decision making, processes for facilitating passengers and/or cargo and freight at airports, which will allow agreed performance parameters to be met by the ATM system partners	2.3.1; 2.3.2; 2.3.7
R101	Ensure that ATM system design, development, implementation and operation are determined by collaborative decision making, system safety and system-wide business cases	2.1.9 b)
R102	Ensure that all safety practices and processes are explicit and that they comply with the safety requirements and standards of ICAO, State regulatory authorities and other appropriate parties	Appendix F, 2.2.3
R103	Ensure that any performance management system establishes rules for, among other things, performance measurement, performance maintenance, performance management and performance enhancement	Appendix F, 2.5.12
R104	Deleted	
R105	Recognize the principles of access and equity in the organization, flexible allocation and use of airspace	2.2.1
R106	Manage airspace dynamically and flexibly based on services demanded	2.2.5 a)
R107	Adapt airspace organizational boundaries, divisions and categories based on traffic patterns, changing situations and unplanned requirements, supporting efficient operation of the other ATM services while not being constrained by national or facility boundaries	2.2.5 a)
R108	Operate on the principle that all airspace is the concern of the ATM system and is a usable resource, and any restriction on the use of any airspace will be considered transitory	2.2.1
R109	Operate on the principle that all airspace will be managed and all related activity within airspace will be known to the ATM system to the degree necessary to meet performance expectations	2.2.6
R110	Deleted	
R111	Ensure that all available capacity is fully and efficiently used	2.3.3
R112	Establish a collaborative process to allow for efficient management of the air traffic flow through use of information on system-wide air traffic flow, weather and assets	2.1.4; 2.4.1

ATM requirement number	Requirement	OCD reference
R113	Utilize system-wide balancing techniques to collaboratively resolve local demand and capacity-balancing problems	2.4.4 e)
R114	Consider current and predicted airspace conditions and projected demand as well as past performance	2.4.4 g)
R115	Recognize that traffic synchronization encompasses both the ground and the airborne part of the ATM system and constitutes a flexible mechanism for capacity management	2.5.2
R116	Allow airspace users to fly user-preferred trajectories that are consistent with the applicable airspace management requirements and aircraft capabilities	2.6.11
R117	Limit, to an acceptable level of safety, the risk of collision between aircraft and hazards	2.1.8; 2.7.1
R118	Apply separation provision only when strategic conflict management cannot be used effectively	2.7.13
R119	Define the predetermined separator prior to commencement of separation provision; however, the role of separator may be delegated	2.7.19
R120	Designate the airspace user as the predetermined separator, unless safety or ATM system design requires a separation provision service	2.1.8 b); 2.7.19
R121	Establish an on-request basis for ATM service delivery	2.8.1
R122	Manage distribution of responsibilities for the various services and their seamless performance, including designation of the predetermined separator for separation provision	2.8.3
R123	Assemble the best possible integrated picture of the historical, real-time and planned or foreseen future state of the ATM system situation and make relevant quality-assured and accredited information available to the ATM system	2.9.3
R124	<ul style="list-style-type: none"> a) Ensure appropriate levels of security; b) Recognize that the requirements associated with security may vary from time to time and according to location; and c) Coordinate these requirements through strategic, pre-tactical and tactical collaborative decision making to allow agreed performance parameters to be met by ATM system partners 	2.2.7; 2.3.7; 2.3.8
R125	Operate on the basis that all operations are known to the ATM system	2.2.6
R126	Provide a collaboratively agreed minimum notice period in which a State or region intends to change or withdraw the existing infrastructure and/or services	2.2.2; 2.2.3; 2.2.9; 2.2.11 a); 2.2.11 g)

ATM requirement number	Requirement	OCD reference
R127	Establish and monitor agreed environmental performance targets to ensure that the expectation of society for the aviation industry contribute to the reduction of impacts on the environment, including noise, gaseous emissions, and the effect on the amenity of particular areas is met	2.2.7; 2.3.8; Appendix D (Environment)
R128	Facilitate collaborative decision making between the appropriate community members and environmental authorities to ensure that a balance exists between the need to mitigate the effects of the ATM system on the environment, and the economic benefit to States derived from operation of the ATM system	2.2.7; 2.3.8
R129	Ensure that where they are required, validation and cost-benefit analysis ¹ are achieved through focused research and development and establishment of business cases ¹ prior to implementation of the changes	2.1.9 b)
R130	Deleted	
R131	Establish contingency plans at all levels of operation to deal with anomalies/disruptions and to ensure safety and an appropriate level of operations	1.4 (Guiding Principles: Continuity); Appendix D (Capacity)
R132	<ul style="list-style-type: none"> a) Ensure that in supporting ATM system expectations, the developers of telecommunications systems ensure that harmful interference will neither be caused by, nor received from, other authorized users; b) Establish and maintain frequency and spectrum allocation and management assistance programmes 	1.4 (Guiding Principles: Technology)
R133	Provide frequency and spectrum management assistance to all new and existing programmes to ensure that national and international standards are complied with and that no new items of equipment are introduced that would interfere with existing systems	1.4 (Guiding Principles: Technology)
R134	Be based on the principle that the safety of the ATM system, or its components and parts, is evidence-based	1.4 (Guiding Principles: Safety); 1.7; Appendix F
R135	Support system safety with lead indicator and causal factor analysis, in addition to traditional lag indicator statistical analysis in the ongoing monitoring of safety	1.4 (Guiding Principles: Safety); Appendix F
R136	<ul style="list-style-type: none"> a) Give due consideration to the interaction of humans and technology, for example, the “human-machine interface” in the design of the ATM system or its parts; b) Demonstrate this consideration in the safety analysis accompanying the system design 	1.4 (Guiding Principles: Safety, Humans); Appendix F, 2.2.3 and 2.5.23
R137	Guard against the potential to create a safety hazard by information overload	1.4 (Guiding Principles: Safety, Humans); 2.9.14

1. Refer to Appendix D of this manual for further information on cost-benefit analysis and business case.

ATM requirement number	Requirement	OCD reference
R138	Be designed so that the human is never in doubt as to the ongoing status of the ATM system or the flight environment as appropriate to the human task undertaken	1.4 (Guiding Principles: Humans); 2.7.29; 2.7.30; 2.8.6
R139	Deleted	
R140	Ensure that ATM system safety is maintained during any transition	1.4 (Guiding Principles: Safety)
R141	Define common safety indicators to be used by all States	2.3.4; Appendix F, 2.3.12
R142	Deleted	
R143	Predict potential saturation of airspace or aerodromes in advance and to a level of accuracy to meet ATM system performance objectives	2.2.6; 2.2.7; 2.3.3; 2.4.1; 2.4.2; 2.4.3; 2.8.4; 2.8.6; 2.9.2
R144	Deleted	
R145	Provide a capability to meter traffic to achieve a balance between traffic demand and the capacity of the ATM system	2.2.6; 2.2.7; 2.3.3; 2.4.1; 2.4.2; 2.4.3; 2.8.4; 2.8.6; 2.9.2
R146	Provide a capability to evaluate the effectiveness of flow restrictions implemented in the ATM system. Effectiveness criteria shall include overall system performance measures	2.2.6; 2.2.7; 2.3.3; 2.4.1; 2.4.2; 2.4.3; 2.8.4; 2.8.6; 2.9.2
R147	Deleted	
R148	Work to reduce voice communications as far as is practicable in delivery of ATM services	1.4 (Guiding Principles: Technology)
R149	Be based on self-contained navigation supported primarily by on-board and/or space-based systems, as far as is practicable	1.4 (Guiding Principles: Technology)
R150	Operate on the basis that services to airspace users will be based on the actual navigation performance of the users at the time of service. Where navigation performance requirements are specified, they will be determined on the basis of the navigation accuracy required in a given volume of airspace and/or through specific procedures to maintain appropriate levels of safety with respect to other hazards	1.4 (Guiding Principles: Technology)
R151	Demonstrate an increased responsiveness across the spectrum of ATM services to real-time changes in airspace user needs. Furthermore, the system should provide the user with at least one alternative in case of changes imposed by the ATM system	2.8.2

ATM requirement number	Requirement	OCD reference
R152	Operate on the basis that where surveillance performance requirements are specified, they will be determined on the basis of the accuracy of position determination (and subsequent display) required in a given volume of airspace and/or specific procedure to maintain appropriate levels of safety with respect to other hazards	1.4 (Guiding Principles: Technology)
R153	Operate on the basis that where there is a conflict between access and equity, allocation of priority to airspace users will be based on the principle of maximizing ATM system performance	2.2.11 c)
R154	Operate on the basis that ATM service delivery will participate in determination of airport capacity and will be aware of the available airport capacity at relevant airports at all times to be able to maximize use of that capacity	2.3.3, 2.8.4
R155	Ensure that appropriate mechanisms are established and maintained to ensure appropriate authority, responsibility and data control of all ATM system information so that the various parties use a coherent set of data	2.8.4, 2.9.3
R156	Deleted	
R157	Establish standards for meteorological model accuracy and resolution and agree on performance requirements	2.9.18
R158	<ul style="list-style-type: none"> a) Establish quality of service requirements to support provision of services within the ATM system; and b) Ensure that quality of service includes performance requirements related to availability, continuity, reliability and integrity. 	Appendix F
R159	Facilitate provision of ATM system demand and capacity projections to relevant ATM community members for up to an agreed/specified time in advance	2.3.3; 2.4.1; 2.4.2; 2.4.3; 2.8.4; 2.8.6; 2.9.2
R160	Facilitate, as appropriate and on request, conduct of capacity and demand projections and make the results of that analysis available to the ATM service delivery management function	2.2.6; 2.2.7; 2.3.3; 2.4.1; 2.4.2; 2.4.3; 2.8.4; 2.8.6; 2.9.2
R161	Provide the capability to evaluate the effectiveness of flow restrictions implemented in the ATM system. Effectiveness criteria shall include overall system performance measures	Appendix F
R162	Be designed so that the operation and continued evolution of the ATM system incorporates mechanisms so that information and/or actions concerning emergency and/or unexpected events involving any of the airborne or ground-based ATM community members can be communicated to all ATM system participants who need to respond to or be aware of the event or actions	1.4 (Guiding Principles: Safety)

ATM requirement number	Requirement	OCD reference
R163	Ensure that decisions affecting the evolution of the ATM system are made in consultation with all affected ATM community members	1.4 (Guiding Principles: Collaboration); Appendix D (Participation by the ATM community)
R164	Provide timely access to all relevant meteorological information	2.4.1; 2.9.17
R165	Ensure that in the design of the ATM system, the principles of access and equity are taken into account	Appendix D (Access and equity)
R166	Deleted	
R167	Ensure that environmental issues are considered in the design, development and operation of all aspects of the ATM system	2.3.8; Appendix D (Environment); Appendix I, 3.2
R168	Ensure appropriate levels of security, recognizing that security is most visible in the aerodrome environment and that the requirements associated with security may vary from time to time and according to location	2.2.7; 2.3.7; 2.3.8
R169	Apply traffic synchronization for the purpose of maximizing throughput of a particular ATM environment in the most effective and efficient manner	2.5.1; 2.5.4; 2.5.6 b)
R170	Establish a global ATM system vocabulary with a well-defined form (syntax) and meaning (semantics) such that each participating entity in the exchange will be able to interpret the information provided in precisely the same way. In this context, information is considered to encompass voice, text, data and imagery elements	1.4 (Guiding Principles: Information); 2.9.2; 2.9.10; 2.9.11
R171	Ensure that, in any transaction, each participating ATM community entity uses the global ATM system vocabulary to describe the ATM services that it provides within its area of service provision	2.9.2; 2.9.5; 2.9.11
R172	Ensure that each participating ATM community entity provides a means for other participating entities to identify and access its services. The means for determining and accessing service shall be based on a common description framework and associated method(s) that the participating entities can use to facilitate the introduction and transition to new technologies	1.4 (Guiding Principles: Collaboration); 2.8.1; 2.9.11
R173	Ensure that the communication media/protocols used to support interoperability — both in determining and providing services across discontinuities — are agreed in conformance with internationally approved, open and non-proprietary standards, i.e. the specification of the media protocols and their operational performance must be freely available	2.9.9; Appendix D (Global interoperability)
R174	Ensure application of the system safety approach to all life-cycle phases of the ATM system and its elements, supported by safety cases	Appendix F, 2.2.3

ATM requirement number	Requirement	OCD reference
R175	Ensure that safety data will be recorded, processed and analysed centrally within a State, region or group of States, taking into account the experience of existing State incident reporting schemes; furthermore, safety data will be shared globally	Appendix F, 2.3.10 and 2.3.11
R176	Ensure that ATM community members provide past, current and predicted information as required by the system for predictability of services	Appendix D (Predictability); Appendix E, 2
R177	Ensure that aircraft capabilities will be totally integrated into the collaborative decision-making process of the ATM community and will allow it to comply with all relevant ATM system requirements	2.1.6 f)
R178	Establish procedures reducing any need for departing or arriving aircraft to spend ground time holding for services with engines operating	Appendix I, 7.5
R179	Establish procedures to accommodate arrivals without aircraft having to enter airborne holds for aerodrome service accommodation as a routine	2.4.4 a); 2.5.3; 2.5.4; Appendix D (Efficiency)
R180	Be designed in such a way as to ensure that all pertinent ATM community members are included in relevant collaborative decision making and have easy access to the associated necessary information	1.4 (Guiding Principles: Information, Collaboration); 2.9.3; Appendix D (Participation by the ATM community)
R181	Implement and operate in such a way that the varying and diverse user requirements will be met as closely as technically possible within the defined equity and access	2.4.2; 2.6.8
R182	Use 4-D trajectory control and/or flight deck delegation for aircraft spacing	2.5.6 c)
R183	Monitor and alert when indications are that an aircraft will not be in conformance/compliance with the agreement	2.8.11
R184	Be based on the principle that the operation of the ATM system will not compromise the sovereignty of any State	2.2.2; Appendix A (States)
R185	Treat performance as a whole, that is, considering all the ATM community expectations and their relationships	Appendix D; Appendix E, 1
R186	Ensure the establishment of performance cases (safety, business, environmental, etc.) before implementing changes	1.5.2; 1.10; 2.1.9 b); 2.8.1; Appendix E, 2
R187	Ensure that all information for performance management is available to the concerned parties transparently and that information disclosure rules are in place	2.9.9
R188	Balance the expectations of the ATM community	1.7; Appendix G, 1.1

ATM requirement number	Requirement	OCD reference
R189	Recognize that there are three safety risk bands: intolerable, as low as reasonably practical (ALARP), and broadly acceptable	Appendix F, 2.3.1; Appendix G, 2.7; Figure G-2
R190	Accommodate the determination of levels of safety and risk which may be expressed in various manners	Appendix F, 2.3.4, 2.3.5, 2.3.7
R191	Ensure that safety risk is calculated with scientific rigour; however, also accommodate the determination of safety risk acceptability by value judgement	Appendix F, 2.3.5
R192	Ensure a consistent approach to the collection, evaluation and review of safety-related data, including the understanding of causes and effects that can be applied over time and across segments of the community for the purpose of making informative comparisons	Appendix F, 2.3.11
R193	Ensure that the target level of safety is the minimum level of safety to be achieved	Appendix F, 2.3.2
R194	Be designed so that collision avoidance systems remain a safety net independent from separation provision	2.1.8 f); 2.7.31
R195	Be designed to minimize restriction of access to airspace	2.2.5; 2.4.2
R196	Provide the collaboratively agreed level(s) of capacity	2.4.2; 2.4.5; Appendix I, 4.1
R197	Ensure that sufficient capacity is provided through collaborative decision making	2.4.1; 2.4.3
R198	Ensure that the ATM community works collaboratively to plan and implement the capacity needed to cost-effectively meet the forecast demand	Appendix D (Capacity, Cost-effectiveness)
R199	Minimize the impact of adverse weather on the total ATM system so as to ensure that maximum throughput is generated in all meteorological conditions	2.1.3 ; 2.9.18 c); Appendix E, 3 d)
R200	Provide the ATM community with data essential to the planning of its operations	2.9.3
R201	Enable all airspace users to adjust departure and arrival times and modify flight trajectories dynamically and, where necessary, renegotiating trajectory agreements, thereby permitting them to exploit operational opportunities as they occur	Appendix D (Flexibility)
R202	Address the operational and economic cost-effectiveness of gate-to-gate flight operations from a single-flight perspective	Appendix D (Efficiency)

ATM requirement number	Requirement	OCD reference
R203	Modify the airspace user's preferred trajectory: <ul style="list-style-type: none"> — when required to achieve overall ATM system performance requirements; and/or — collaboratively with the airspace user, in a manner that recognizes the airspace user's need for single-flight efficiencies 	1.9.2; Appendix D (Efficiency); Appendix E, 3 g); Appendix I, 6.13
R204	Be based on global standards and uniform principles, ensure the technical and operational interoperability of ATM systems and facilitate homogeneous and non-discriminatory global and regional traffic flows	1.12; Appendix D (Global interoperability)
R205	Establish common operational procedures within similar operational environments	1.12; Appendix H, 5
R206	Utilize systems standardized at a functional level	1.4 (Guiding Principles: Technology); Appendix G, 1.6
R207	Incorporate interoperability during the design of any changes to the ATM system	1.12; 2.6.5
R208	Ensure the selection and adoption and, where necessary, the development of interoperability standards and related materials that enable mutual exchange of relevant and timely data	1.4 (Guiding Principles: Information); 2.6.5; 2.9.10
R209	Make the best use of aircraft capabilities	2.6.5
R210	Ensure that the interrelationship and interdependency of aircraft design and ATM performance are key considerations in aircraft design	2.6.6; Appendix I, 6.6
R211	Manage surface, departure, and arrival and en-route flow of traffic dynamically to optimize traffic flow or throughput	2.5.3
R212	Consider the trajectory of a vehicle during all phases of flight and manage 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	1.9.2
R213	Define separation modes for separation from all hazards, including weather, applicable to all airspace and movement areas	2.7.4; 2.7.29
R214	Provide rules and means to delegate the role of separator	2.7.19; 2.7.21
R215	Provide separation provision service when required by safety or ATM system design	2.7.27
R216	Ensure that collision avoidance systems activate when the separation mode has been compromised	2.7.31

Appendix B

COLLABORATIVE DECISION MAKING

1. Collaborative decision making (CDM) is about improving the way ATM stakeholders work together in sharing information at all organizational levels to ensure that better air traffic management decisions are made by the right person with the right information and data and the right input from others. By identifying the best sources of data and disseminating that data to key ATM decision makers according to a set of business rules, better decisions can be made, resulting in improved performance of the overall ATM system, including increased capacity, fewer delays and increased operational efficiency. The OCD (*Global Air Traffic Management Operational Concept*, Doc 9854), Appendix I, describes CDM in the following terms:

“10.1 Collaborative decision making will allow all members of the ATM community, especially airspace users, to participate in the ATM decision making that affects them. The level of participation will reflect the level to which a decision will affect them.

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

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

10.4 The time available for achieving a collaborative decision decreases from the strategic to the tactical stages. In the most tactical of situations, there may be no time to consider options; however, wherever such situations can be foreseen, collaborative decision making will have been previously used to determine agreed procedures for such cases. For example, rules for determining priorities for accessing 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 each member of the ATM community to 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 among airspace users directly, without any involvement of an ATM service provider.

Any member of the ATM community can propose a solution

10.7 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 that will propose a solution for consideration by the airspace user because the service provider will be 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 a particular solution has been proposed.

10.8 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."

2. So, collaborative decision making may involve short-term "tactical" in-flight or pre-flight decision making, all the way to long-term strategic issues, such as long-term scheduling, and even fleet and equipment procurement.

Appendix C

“EN-ROUTE TO EN-ROUTE”

INTRODUCTION

1. Ensuring effective performance of the ATM system necessarily requires consideration of not only the actual ATM system itself, but also performance incompatibilities within the ATM system and with immediately adjacent broader transportation system elements. Areas of performance incompatibility within the ATM system may manifest as performance differences between air traffic management components (e.g. airport demand of “X” movements per hour, airport throughput capacity of “X” movements per hour, terminal area traffic management capacity of “X – 5” movements per hour, and next sector capacity of “X” movements per hour). The area of performance incompatibility would be terminal area (TMA) management.
2. A good example of performance incompatibility within the ATM system and immediately adjacent elements is the airport. For example, the throughput demand of an airport may be “X” movements per hour, but the ground handling, parking or facilitation capability of the airport is “X – 5” movements per hour.
3. The traditional view of the ATM system has been a “gate-to-gate” view, which, in practice, disregards the very real impact that landside discontinuities can have on downstream ATM system performance. These discontinuities occur because:
 - a) Airports comprise differing groups; each group operates within different fields with different goals, but all generally aim to maximize safety/throughput profit and minimize environmental impact.
 - b) Services partly share the same resources (e.g. viewed from the airside of an airport: the apron, taxiways, runways and airspace).
 - c) All services have to cooperate to contribute to the common transportation objective.
 - d) The services are the responsibility of different service providers — ATM system or landside.
4. To both properly recognize and therefore treat the effect of non-ATM system activities at airports on ATM system performance, one must complement the “gate-to-gate” view, with an “en-route to en-route” perspective of the ATM system.
5. Figure C-1 shows this view and invites the reader to consider a flight from the middle of one en-route phase, through its approach and landing phase, turnaround at the gate, take-off and climb phase, and flight to the middle of its next en-route phase. This view requires consideration of the so-called “turnaround performance,” not as an ATM system component, but as a point of performance incompatibility, which appropriate members of the ATM system community must manage.
6. The key to optimizing aerodrome operations will be collaborative decision making. This will involve examining the driving elements for each stakeholder and the interdependencies with adjacent stakeholders within their workflow process model. Information of different planning intervals of different stakeholders acting on the aircraft’s turnaround cycle will be taken into account to enhance the whole-of-system capability by downstream dedicated cueing information, which increases quality and stability of plans of “downstream operation centres,” thus increasing the stability of their operations.

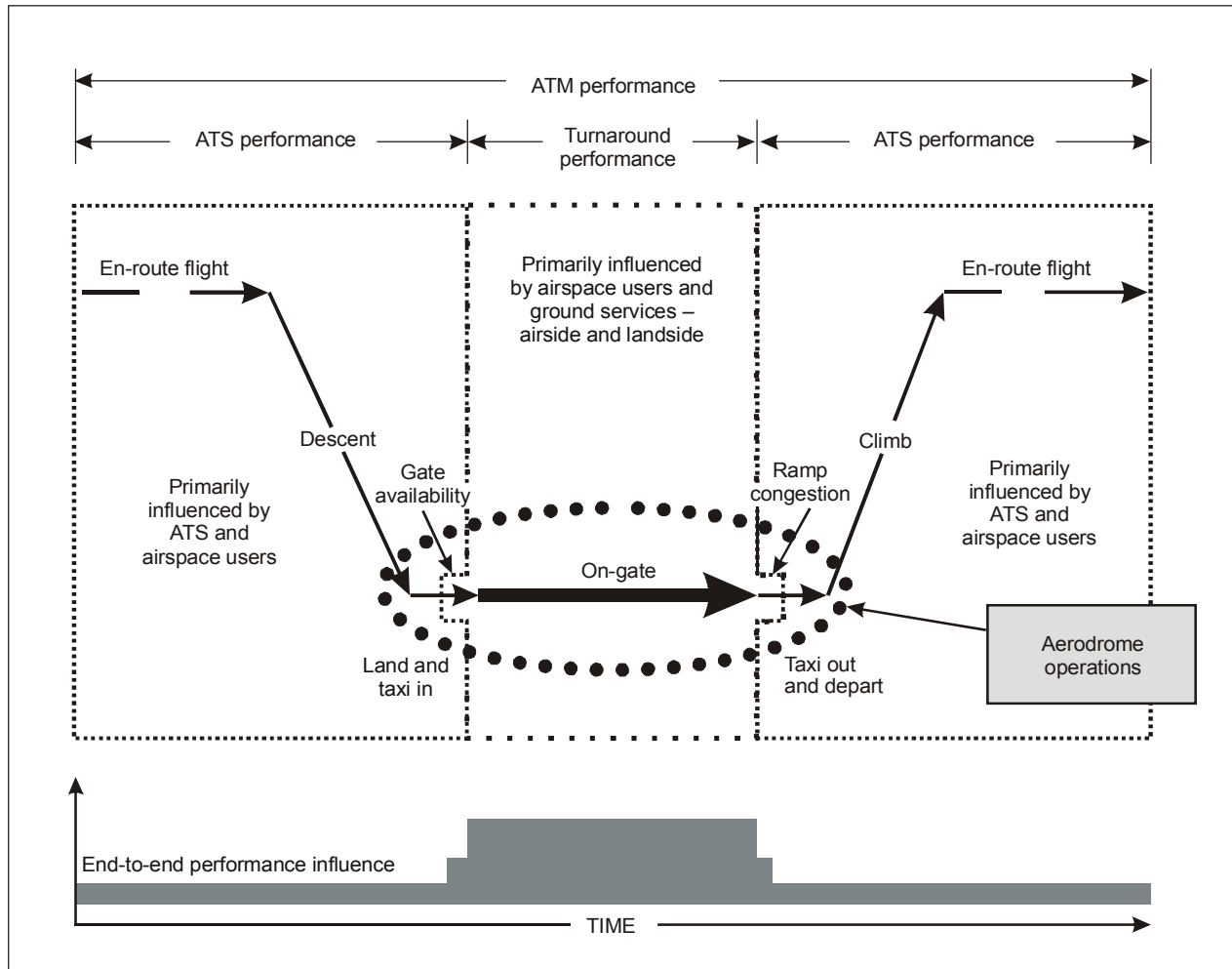


Figure C-1. ATM influences — aerodrome operations — en-route to en-route cycle

7. This stability will provide reliability and predictability, which is critical to the ATM co-components, particularly demand and capacity balancing, traffic synchronization, and airspace organization and management. The main expected benefits to ATM system and landside stakeholders are:

- a) The airport community will benefit from the availability of standardized methods, procedures and interconnected data processing developed through the programme.
- b) Airspace users will benefit from improved quality of airport services, improved techniques and procedures and the introduction of higher levels of automation, improving efficiency and cost-effectiveness of flight operations.
- c) ATM service providers will benefit from standardized performance levels, ensuring safe, reliable and cost-effective services.

8. The main expected benefits to ATM and landside stakeholders are:

- a) The airport community will benefit from the availability of standardized methods, procedures and interconnected data processing developed through the programme.
 - b) Airspace users will benefit from improved quality of airport services, improved techniques and procedures, and introduction of higher levels of automation, improving the efficiency and cost-effectiveness of flight operations.
 - c) ATM service providers will benefit from standardized performance levels, ensuring safe, reliable and cost-effective services.
 - d) Support industries will benefit from standardized specifications for airport equipment and services, enabling greater time for, and cost-efficiency in, design and production.
 - e) International organizations, national and local regulatory authorities and the military authorities will be involved in the airport-related developments, and their legitimate interests and requirements will be taken into account.
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Appendix D

COST-BENEFIT AND BUSINESS CASE

1. Historically, investment evaluations for service providers and operators have been perceived as independent, separate activities with interdependent consequences. Service providers may identify specific technological or procedural advancements intended to lower their operating costs, but often base the planned costs and returns on estimates of operator investments, with no assurance of the accuracy or consistency of the estimates with the operator's business model. Similarly, operators have invested significant resources in technologies in anticipation of realizing internal savings without guaranteed commitment that service providers will fully implement ground-based expenditures upon which the operator's investments are based. Both have suffered failures to capture the gains sought as a direct result of the independent methodologies/analyses employed.

2. As identified in the operational concept, cost-benefit analysis, and specifically the business case, serves as one of the pillars supporting advancement of ATM system performance. Use of structured, transparent business case analyses ensures inclusion of the many facets of the ATM community. Priorities are taken into account in pursuit of the most efficient and cost-effective mechanisms, which are sought, developed and placed into operation. (These facets include consideration of the broader economic and social aspects such as safety, environmental impacts, and so on.)

3. A significant body of work already exists within the community regarding the definitions and conduct of cost-benefit analysis and business cases. From ICAO manuals the following considerations are offered:

Business case evaluation — The development of a business case for the implementation of CNS/ATM systems by a service provider or an operator involves taking the financial cost-benefit analysis a step further. In particular, changes in revenues resulting from changes in the price of the product sold must be taken into account. It is generally expected that CNS/ATM systems will facilitate reduced operating costs and a lower price for the service provided. From the point of view of a specific organization, assessment of the net financial impact, in present value terms, must include not only the implementation cost and operating cost savings, which are included in the cost-benefit analysis, but also consequent changes in revenues (*Global Air Navigation Plan for CNS/ATM Systems* (Doc 9750)).

Cost-benefit analysis (CBA) — An evaluation method that provides a logical and consistent framework for assessing a particular option or options. A CBA gives an indication of the total economic welfare effects of a project by comparing all costs and benefits (*Guidance on the Balanced Approach to Aircraft Noise Management* Doc 9829)).

Cost-effectiveness analysis (CEA) — An evaluation method to be used when the objective of a measure is a given. It differs from a CBA in that it asks a different question; namely, given a particular objective, which is the least costly way of achieving it? (*Guidance on the Balanced Approach to Aircraft Noise Management* (Doc 9829)).

4. As a function of the collaboration agreed in the *Global ATM Operational Concept* and the requirements derived herein, a new approach is envisioned to conduct analysis and advance ATM performance in the most effective manner for all community members. The adoption and practice of strategic collaborative decision making, from identification of performance metrics through establishment of performance targets and culminating in implementation and operation of the agreed, complementary technologies provides the best opportunity to deliver the level and types of services (necessary and requested) at the lowest possible community cost.

5. The requirements articulated in this document seek to reflect the basic tenet of the future vision that development of an agreed performance framework with targets to guide the conduct of collaborative analyses will elevate all aspects of the ATM system, to the advantage of all community members.

Appendix E

EXPECTATIONS

The eleven expectations below are drawn directly from Appendix D of the OCD (*Global Air Traffic Management Operational Concept*, Doc 9854). 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 members of 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 right of access to the ATM resources needed to meet their specific operational requirements and that the shared use of airspace by different users can be achieved safely. The global ATM system should ensure equity for all 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 that priority be determined on a different basis.

Capacity

The global ATM system should exploit the inherent capacity to meet airspace user demands 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 on safety and 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 policies and principles regarding user charges should be followed.

Efficiency

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

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 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 that stem from intentional acts (e.g. terrorism) or unintentional acts (e.g. human error, natural disaster) 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 that 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 the authorities responsible with appropriate assistance and information.

Appendix F

EXPLANATION OF TERMS

Most of the explanations of the following terms stem directly from the OCD (*Global Air Traffic Management Operational Concept*, Doc 9854) and should be read in that context. Except where indicated, they have no official status within ICAO. Where a term is used differently from a formally recognized ICAO definition, this is noted.

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

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.

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

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 and ground- and/or space-based communications, navigation and surveillance.

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.

ATM operational concept. The ATM operational concept is a high-level description of the 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 to be 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 system requirement. A statement of functionality and/or operating characteristics necessary to fulfil the capabilities or benefits envisioned in the application of the global ATM operational concept.

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.

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.

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

Capability. The ability of a system 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. 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 a hazard in which the applicable separation minima may be compromised.

Constraint. Any limitation on the implementation of an “operational improvement”.

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

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

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

Efficiency. The ratio of the cost of ideal flight to the cost of procedurally constrained flight.

Enablers. Initiatives, such as (new) technologies, systems, operational procedures, and operational or socio economic developments, 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 that priority be provided 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 the 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, terrain, and ATM service constraints), calculated and “owned” by the aircraft flight management system, and agreed by the pilot.

Gate to gate. A concept where the air traffic operations of ATM community members 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. The objects or elements that an aircraft can be separated from. These are: other aircraft, terrain, weather, wake turbulence, incompatible airspace activity and, when the aircraft is on the ground, surface vehicles and other obstructions on the apron and manoeuvring area. For any hazard (i.e. any condition, event or circumstance that 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. The terms accident and incident are defined in Annex 13 — *Aircraft Accident and Incident Investigation*.

Interoperability. Within the ATM system, is the ability to transfer information or to effect a functionality across any discontinuity (perceived or otherwise), in order to enable operations, thereby eliminating the effect of the discontinuity.

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 term 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 prerequisite for, or an enabler of, an operational improvement, another enabler or a line of action.

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

- a) a high-level description of the ATM services necessary to accommodate traffic at a given time horizon;
- b) a description of the anticipated level of performance required from, and the interaction between, the ATM services, as well as the objects they affect; and
- c) a description of the information to be provided to agents in the ATM system and how that information is to be 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 personnel functions. 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 “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, 2025 was selected as the 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.

Operational control.² A term used generically with respect to a flight, which means the exercise of authority over the initiation, conduct and termination of 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. When 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.

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 about risk.

Safety case. Both the argument and the document that contend that 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 below.

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

Seamlessness. Within the ATM system, is the property that allows a transition across any discontinuity (perceived or otherwise), which from the perspective of the transiting agent does not require effort to facilitate the transition, thereby eliminating any impact imposed by the discontinuity.

Separation minima. The minimum displacements between an aircraft and a hazard which maintain the risk of collision at 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.

Separator. The 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 predetermined 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 a safe and orderly flow of traffic.

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

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, all disciplines and all system life-cycle phases.

Traffic synchronization. Traffic synchronization concerns the management of the flow of traffic through merging and crossing points, such as traffic around major aerodromes or airway crossings. It currently includes the management and provision of queues both on the ground and in the air. Traffic synchronization, as a function, is closely related to both demand/capacity balancing and separation provision and may in the future be indistinguishable from them. Traffic synchronization also concerns the aerodrome “service” part of the concept.

Trajectory or profile. This is a description of the 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 Convention on International Civil Aviation, 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 G

ACRONYMS

ALARP	As low as reasonably practical
AO	Aerodrome operations
AOM	Airspace organization and management
ATM	Air traffic management
ATMCP	Former Air Traffic Management Operational Concept Panel
ATMRPP	Air Traffic Management Requirements and Performance Panel
AUO	Airspace user operations
CDM	Collaborative decision making
CM	Conflict management
CNS	Communications, navigation and surveillance
DCB	Demand and capacity balancing
FMS	Flight management system
ICAO	International Civil Aviation Organization
IM	Information management
OCD	Operational concept document
OR	Operational requirement
PIRG	Planning and implementation regional group
R	ATM system requirement
SDM	Service delivery management
TMA	Terminal area
TS	Traffic synchronization
4-D	Four-dimensional (lateral, longitudinal, vertical, temporal)

— END —

ICAO TECHNICAL PUBLICATIONS

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

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

Procedures for Air Navigation Services (PANS) are approved by the Council for worldwide application. They contain, for the most part, operating procedures regarded as not yet having attained a sufficient degree of

maturity for adoption as International Standards and Recommended Practices, as well as material of a more permanent character which is considered too detailed for incorporation in an Annex, or is susceptible to frequent amendment, for which the processes of the Convention would be too cumbersome.

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

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

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

Air Navigation Plans detail requirements for facilities and services for international air navigation in the respective ICAO Air Navigation Regions. They are prepared on the authority of the Secretary General on the basis of recommendations of regional air navigation meetings and of the Council action thereon. The plans are amended periodically to reflect changes in requirements and in the status of implementation of the recommended facilities and services.

ICAO Circulars make available specialized information of interest to Contracting States. This includes studies on technical subjects.

