

**Doc 9882**  
**AN/467**



# Manual on Air Traffic Management System Requirements

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Approved by the Secretary General  
and published under his authority

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Téléphone: +221 839 9393; Fax: +221 823 6926; Sitatex: DKRCAYA; Courriel: icaodkr@icao.sn

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*Thailand.* ICAO Regional Director, Asia and Pacific Office, P.O. Box 11, Samyae Ladprao, Bangkok 10901  
Telephone: +66 2 537 8189; Facsimile: +66 2 537 8199; Sitatex: BKKCAYA; E-mail: icao\_apac@bangkok.icao.int

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## RECORD OF AMENDMENTS AND CORRIGENDA

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# TABLE OF CONTENTS

|                                                                                                                                              |            |
|----------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>Chapter 1. Overview .....</b>                                                                                                             | <b>1-1</b> |
| 1.1 Relationship between <i>ATM System Requirements, Performance-based Transition Guidelines</i> and <i>Global Performance</i> .....         | 1-1        |
| 1.2 Document intent .....                                                                                                                    | 1-1        |
| 1.3 Document structure .....                                                                                                                 | 1-2        |
| 1.4 Description of the ATM system requirements .....                                                                                         | 1-4        |
| <b>Chapter 2. ATM system requirements .....</b>                                                                                              | <b>2-1</b> |
| 2.1 Performance and expectations .....                                                                                                       | 2-1        |
| 2.2 Information management and services .....                                                                                                | 2-7        |
| 2.3 System design and engineering .....                                                                                                      | 2-10       |
| 2.4 ATM system components .....                                                                                                              | 2-13       |
| <b>Appendix A. List of requirements cross-referenced to the<br/>Global Air Traffic Management Operational Concept (OCD) (Doc 9854) .....</b> | <b>A-1</b> |
| <b>Appendix B. Collaborative decision making .....</b>                                                                                       | <b>B-1</b> |
| <b>Appendix C. “En-route to en-route” .....</b>                                                                                              | <b>C-1</b> |
| <b>Appendix D. Cost-benefit and business case .....</b>                                                                                      | <b>D-1</b> |
| <b>Appendix E. Expectations .....</b>                                                                                                        | <b>E-1</b> |
| <b>Appendix F. Explanation of terms .....</b>                                                                                                | <b>F-1</b> |
| <b>Appendix G. Acronyms .....</b>                                                                                                            | <b>G-1</b> |

# 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.

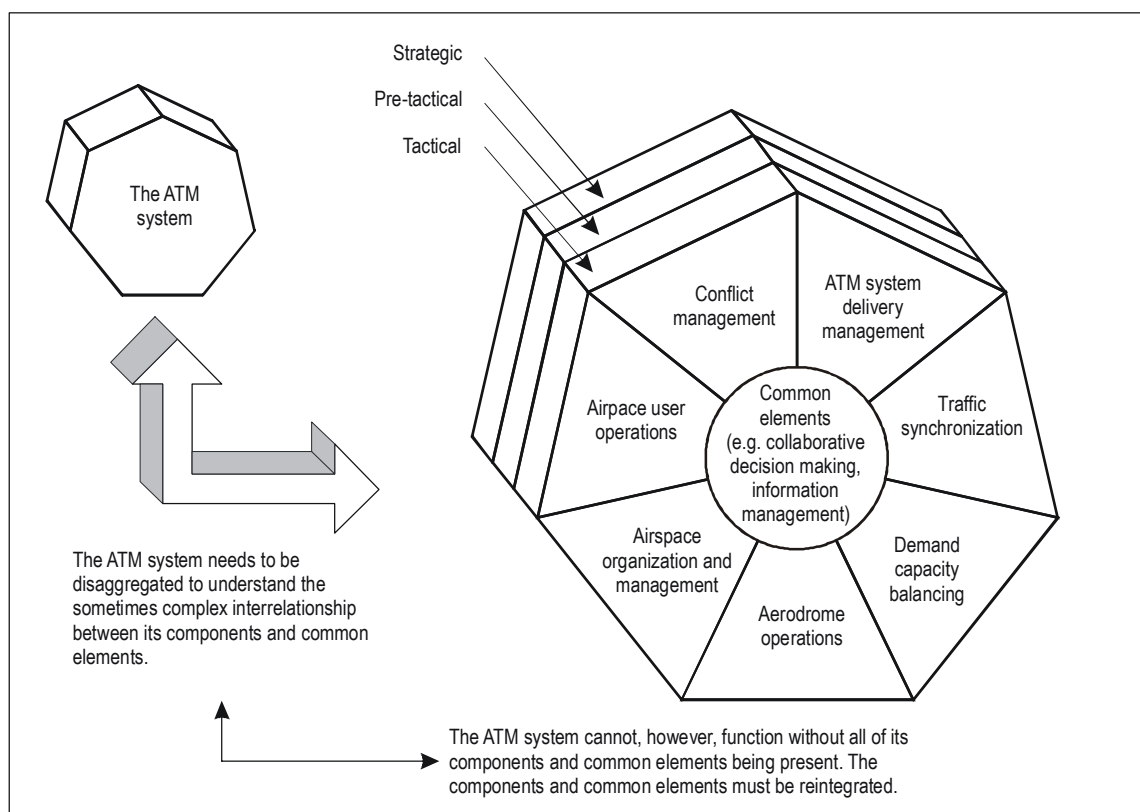


**Figure 1-1. ATM system components**

## 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 analysis<sup>1</sup> are achieved through focused research and development and establishment of business cases<sup>1</sup> 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 nav aids 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*