PERFORMANCE BASED TRANSITION GUIDELINES

Submitted by the ICAO Secretariat

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PERFORMANCE BASED TRANSITION GUIDELINES

Foreword

This document's main objectives are threefold:

Firstly, to raise awareness for the need to change the way in which the evolution of Air Traffic Management (ATM) is planned at local, regional and global level. In the past, planning was very much technology and/or solution driven, with insufficient advance knowledge of resulting performance improvement. Today and in the future, planning choices increasingly need to be justified in advance by a thorough analysis of anticipated performance needs and achievements. Such an explicit management and planning of ATM performance is needed to ensure that throughout the transition process, the expectations of the ATM community are met.

Secondly, to provide "getting started" guidance on how to adopt such a performance based approach in the transition from today's ATM system towards the future ATM system as described in the Global Air Traffic Management Operational Concept (Doc 9854).

Thirdly, to promote a globally harmonized and agreed approach to transition planning in order for Regions and States to work collaboratively in developing their future transition arrangements towards the ATM system envisioned in the Global ATM Operational Concept.

The document is relatively short and written at high level; its scope is purposely limited to providing a broad overview of the tasks that need to be undertaken to adopt a performance based transition approach.

For complementary and more detailed information, the reader is referred to the following documents:

Global Air Traffic Management Operational Concept (Doc 9854) — provides the overall vision;

ATM System Requirements Supporting the Global Air Traffic Management Concept— elaborates the overall vision into material specifying the functional evolution of ATM;

Global Air Navigation Plan for CNS/ATM Systems (Doc 9750) (Global Plan) — focuses on implementation planning guidance.

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1 Introduction and Overview

1.1 Purpose

This document's main objectives are threefold:

Firstly, to **raise awareness** for the need to change the way in which the evolution of *Air Traffic Management*[1] (ATM) is planned at *local*, *regional* and *global level*. In the past, planning was very much technology and/or solution driven, with insufficient advance knowledge of resulting performance improvement. Today and in the future, planning choices increasingly need to be justified in advance by a thorough analysis of anticipated performance needs and achievements. Such an explicit management and planning of ATM performance is needed to ensure that throughout the transition process, the expectations of the *ATM community* are met.

Secondly, to **provide "getting started" guidance** on how to adopt such a performance based approach in the transition from today's *ATM system* towards the future *ATM system* as described in the *Global Air Traffic Management Operational Concept* (Doc 9854).

Thirdly, to **promote a globally harmonized and agreed approach to transition planning** in order for Regions and States to work collaboratively in developing their future transition arrangements towards the *ATM system* envisioned in the *Global ATM Operational Concept*.

1.2 Scope and related documents

This document is dealing with a process and techniques for strategic (time horizon until twenty years ahead) *performance management* and *transition roadmap* development, in the context of *regional* ATM planning. The process produces important inputs to *regional* and *local research* and *implementation planning* (time horizon typically five years).

Aimed at providing "getting started" guidance, the document is relatively short and written at high level; its scope is purposely limited to providing a broad overview of the tasks that need to be undertaken to adopt a *performance based transition approach*.

For complementary and more detailed information, the reader is referred to the following documents:

- *Global Air Traffic Management Operational Concept* (Doc 9854) — provides the overall vision;
- *ATM System Requirements Supporting the Global Air Traffic Management Concept* — elaborates the overall vision into material specifying the functional evolution of ATM;
- *Global Air Navigation Plan for CNS/ATM Systems* (Doc 9750) (*Global Plan*) — focuses on *implementation planning* guidance.

[1] In this document, text in *italics* refers to terms defined in the glossary (section 1.6).

In accordance with the Performance Based Transition Guidelines the ATMRPP will develop subsequently more detailed information regarding *performance management* aspects in the form of an ATM Performance Manual.

1.3 Context and applicability

The *Global ATM Operational Concept* was developed in order to achieve an interoperable, *global air traffic management system* for all users during all phases of flight that meets agreed levels of safety, provides for optimum economic operations, is environmentally sustainable and meets national security requirements. The operational concept describes an *ATM system* in 2025 based on the provision of services and driven by the need to meet the expectations of the *ATM community*. The transition to the operational concept is to occur in a focused way via a set of coordinated planning processes which operate at *local*, *regional* and *global level*.

In terms of level of detail, these planning processes produce three kinds of outputs which will be regularly updated according to the need (see section 1.4):

- **Transition roadmaps**, which are a high level representation of the selection of *operational improvements* and their *deployment* interdependencies (in terms of prerequisites), adapted to the needs of a particular planning area (at *regional* or *local level*).
- **Implementation plans**, which are intended to be derived from the *short term* part of *transition roadmaps*. They lay out a detailed set of *development* and *deployment* actions — including their timing — for all involved members of the *ATM community*.
- **Research plans**, which lay out the *research* needed today to develop the medium and *long term* parts of *transition roadmaps* to a level of maturity suitable for turning them into *implementation plans*.

Transition roadmaps are considered to be at a more strategic level than plans, not only because they contain less detail, more uncertainty and provide guidance for the development of plans, but also because they usually cover a longer time horizon. This is illustrated in Figure 1.

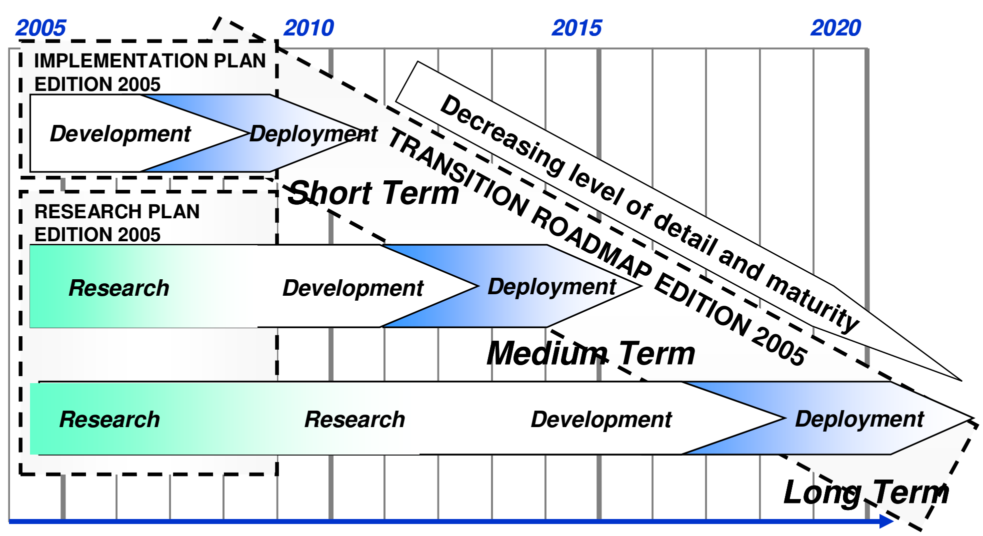

Figure 1 Distinction between implementation plan and transition roadmap

The performance based approach applies to the development of *transition roadmaps* as well as plans. However, in this document the focus is on showing how to include the approach in the development of *transition roadmaps*.

1.4 Overview of the transition planning process

Transition planning is a cyclic process executed at *global*, *regional* and *local level*. It is typically repeated at five year intervals to take into account changing forecasts, up-to-date information on *implementation* progress, new *performance assessments*, changed performance expectations and policies (resulting in revised *performance targets*), and any other relevant change. (Exceptional changes may lead the *ATM community* to decide to start a new *transition planning cycle* before the regular five year interval has elapsed.)

Each iteration results in updated versions of *transition roadmaps*, *research plans* and *implementation plans* (the latter two may be updated on an annual basis). Considering that *transition roadmaps* typically cover a time horizon of twenty years, a given five year period will be updated several times in the *transition roadmap* before it is incorporated into *implementation plans* and finally materializes as a set of real changes to the *ATM system*.

The sequence of steps outlined in section 1.5 takes the results (*transition roadmap*, plans, and *performance assessments*) of the previous iteration into account, and applies all the latest changes to see whether the *transition roadmaps* and plans are still valid from a performance perspective. If this is not the case, *transition roadmaps* and plans are modified to mitigate all identified performance issues (*performance gaps*) and ensure alignment at *global*, *regional* and *local level* (see chapter 4), and the process is ready to start again five years later.

1.5 Overview of the performance based transition approach

Figure 2 provides an overview of the *performance based transition approach*. It contains five steps with questions, which must be answered as part of applying the approach:

- Step 1 (questions 1 - 5): translate *ATM community expectations* into quantified *performance targets*
- Step 2 (questions 6 - 8): conduct *performance assessment* and use *performance targets* to identify current and anticipated *performance gaps*
- Step 3 (questions 9 - 12): update *transition roadmaps* and plans to mitigate identified *performance gaps*
- Step 4 (not shown in the figure): analyze steps 1-3 and generate lessons learned
- Step 5 (not shown in the figure): maintain the guidance material and the overall planning process itself

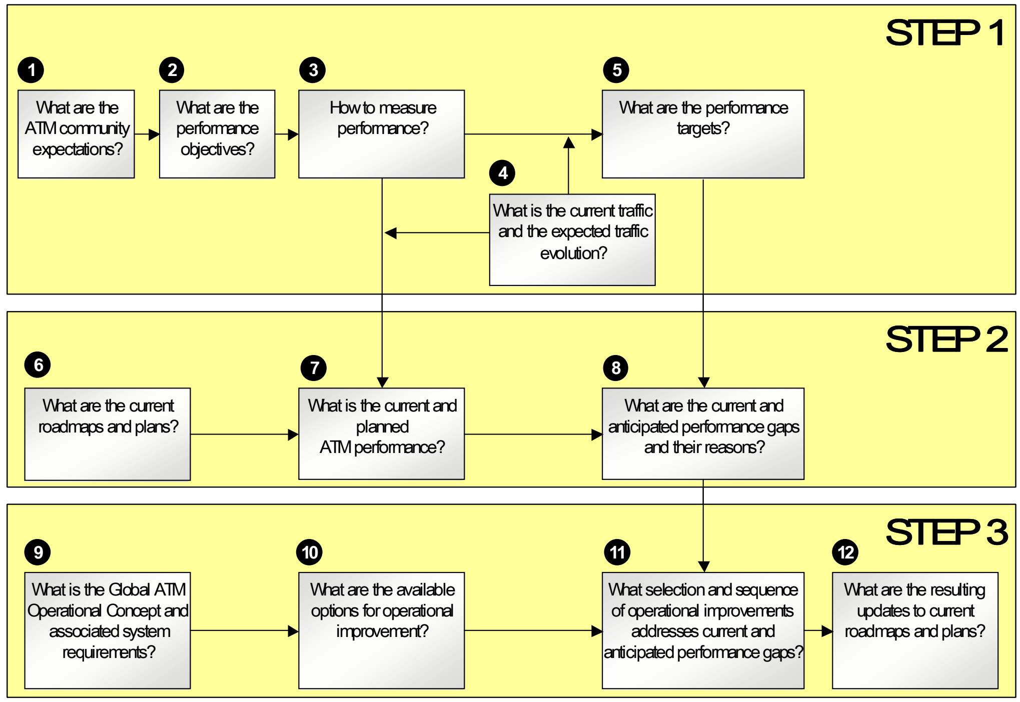

Figure 2 Performance based transition approach

The remainder of this section gives a brief overview of the role of each step in the approach. Subsequent chapters provide more detail:

- Chapter 2 (Measuring and Assessing Performance) addresses steps 1 and 2;
- Chapter 3 (Addressing Performance Gaps) deals with step 3;
- Chapter 4 (Ensuring Alignment Throughout the Planning Process) addresses steps 4 and 5, as well as collaboration issues which arise due to the distributed nature of planning and the layered organization of the process (at *global*, *regional* and *local level*). The underlying philosophy can be described as "Think global, act local".

1.5.1 What are the ATM community expectations?

The *ATM community expectations* are a set of general, high level expectations listed in Doc 9854 (*Global Air Traffic Management Operational Concept*). These are (in alphabetical order): Access and Equity, Capacity, Cost Effectiveness, Efficiency, Environment, Flexibility, *Global* Interoperability, Participation by the *ATM community*, Predictability, Safety, and Security. These expectations are used in *performance management* as the framework for *Key Performance Areas* (*KPA*).

See also: section 2.2.1 on page 17.

1.5.2 What are the performance objectives?

The *ATM community expectation* embodied by each *Key Performance Area* will be met by pursuing more specific *performance objectives*. These are defined to assist the *ATM community* in producing relevant and timely enhancements (*operational improvements*) to a given *region's ATM system*, in order to satisfy the *ATM community expectations*.

Performance objectives are expressed in qualitative terms, and may include a desired or required trend for a *performance indicator* (e.g., reduce the cost per kilometre flown) while not yet expressing the *performance objective* in numeric terms (this is done as part of *performance target* setting). Care has to be taken to ensure that the agreed *performance objectives* are "SMART" — (specific, measurable, achievable, relevant and timely).

See also: section 2.2.2 on page 18.

1.5.3 How to measure performance?

In order to be able to measure performance, a number of definitions, methods and facilities must be put in place:

- For each *performance objective*, *performance indicators* need to be defined to measure the achievement of the *performance objective*. For example, the *performance objective* of "reducing cost per kilometre flown" requires the "cost per kilometre flown" *performance indicator*. *Performance indicators* should be chosen to convey meaningful information about ATM performance for a given *performance objective*, and be suitable to trigger improvement and change.
- In addition, a set of *supporting metrics* must be defined. In the prior example, total cost and total distance flown are required metrics to compute the *performance indicator*. *Supporting metrics* determine which data needs to be collected to calculate values for the *performance indicators*.
- Common definitions need to be agreed for geographical areas, time periods and other categories for which data is collected and published. This is essential for the compatibility of data and determines how performance data can be aggregated (e.g. geographically from *local* to *regional* and — as required — to *global level*).
- Harmonized methods and facilities need to be established for collecting, cleaning, storing, analyzing and disseminating performance data.

An example of existing *performance objectives* and *performance indicators* in the area of environment can be found in Appendix A of Resolution A35-5, adopted by the 35th Session of the Assembly. Specific goals are set to:

- limit or reduce the number of people affected by significant aircraft noise;
- limit or reduce the impact of aviation emissions on local air quality; and
- limit or reduce the impact of aviation greenhouse gas emissions on the global climate.

See also: section 2.2.3 on page 18.

1.5.4 What is the current traffic and the expected traffic evolution?

Traffic (demand) patterns, *volumes*, performance envelopes and equipage change through time.

Demand evolution forecasts need to be produced on the basis of a number of forecasting scenarios (i.e. sets of assumptions about the future), to quantify how the need for performance evolves through time and varies by geographical area and other categorization criteria. As part of this task, data on current and past *traffic patterns* and *volumes* needs to be collected.

See also: section 2.2.4 on page 19.

1.5.5 What are the performance targets?

The above-mentioned *performance indicators* are the agreed way for quantifying how well *performance objectives* have been achieved.

Performance targets are closely associated with *performance indicators*: they represent the values of *performance indicators* that need to be reached or exceeded to consider a *performance objective* as being fully achieved. Note that *performance targets* can be set as a function of time (e.g. to plan year-on-year improvement); they can also vary by geographic area.

A decision-making / policy-making process needs to be in place to collaboratively agree on *performance objectives*, *performance indicators* and the values of *performance targets* at the *local*, *regional* and — where required — the *global level*.

See also: section 2.2.5 on page 20.

1.5.6 What are the current transition roadmaps and plans?

Current *transition roadmaps* and *implementation plans* need to be known and taken into account in the *performance based transition approach*. They are the basis for determining what the currently envisaged performance improvement is.

See also: section 2.3.2.1 on page 23.

1.5.7 What is the current and anticipated ATM performance?

Knowledge about the current *ATM system* and the current traffic levels is used to determine current performance levels, which are to be expressed in terms of the *performance indicators* associated with the various *performance objectives*.

In addition, existing knowledge — obtained from past *validation* activities — needs to be combined with the traffic forecast to assess the future (anticipated) ATM performance.

See also: section 2.3.2 (page 23); in particular 2.3.2.3 on page 24.

1.5.8 What are the current and anticipated performance gaps and their reasons?

The previous step produces current and anticipated values for each of the *performance indicators*, under certain assumptions (forecasting scenarios and existing *transition roadmaps* and plans). These are compared against the latest version of the agreed *performance targets*, resulting in the identification of current and anticipated *performance gaps*.

The underlying reasons for the gaps should be identified:

- Have the *performance targets* been changed?

  - Has there been a change of policy (decision to set more challenging *performance targets*)?
  - Is the *performance gap* caused by a change in the expected traffic evolution (more challenging)?

- And/or are current and anticipated performance not as good as thought during the previous *planning cycle*?

  - Has there been a problem with *implementation* since the previous *planning cycle* (e.g. *implementation* delays)?
  - Have the performance improvement estimates associated with *transition roadmaps* and plans been revised downwards since the previous *planning cycle*?

See also: section 2.4 on page 24.

1.5.9 What is the Global ATM Operational Concept and associated system requirements?

The ICAO vision of an integrated, harmonized and globally interoperable *ATM system* for a planning horizon up to and beyond 2025 can be found in the *Global ATM Operational Concept* (Doc 9854). The purpose of the operational concept document is to set the common goal.

This vision and its envisaged performance characteristics is further detailed in a set of system requirements which can be found in the document entitled *ATM System Requirements Supporting the Global Air Traffic Management Concept* (awaiting publication).

Together, these documents form the guidance material for determining the available options for *operational improvement* (see next section).

See also: section 3.1.4 on page 31.

1.5.10 What are the available options for operational improvement?

Operational improvements are changes to the *ATM system* that are on the transition path towards the *Global ATM Operational Concept* and result in a direct performance enhancement. Because of their need to deliver performance, the elementary changes that make up an *operational improvement* are intended to be implemented together. An *operational improvement* is a transition step in a *transition roadmap*.

A common list of possible *operational improvements* needs to be compiled to deliver the list of options from which to develop *transition roadmaps* adapted to the specific needs of each *region*. The *Global Air Navigation Plan for CNS/ATM Systems* (Doc 9750) (*Global Plan*) is one of the sources for developing the list of candidate *operational improvements* for a *region*. Use can also be made of work undertaken in other planning *regions*. A few illustrations are given in Appendix A of this document.

See also: section 3.1 on page 30.

1.5.11 What selection and sequence of operational improvements addresses current and anticipated performance gaps?

The answer to this question will be provided by a new version of the *transition roadmap* for a particular *region*.

During this step, the *ATM community* needs to modify the old version of the *transition roadmap* and re-assess the performance impact of the changes. The resulting new *transition roadmap* is acceptable if the *ATM community* believes it has a realistic potential for mitigating the *performance gaps*. Such confidence will be underpinned by a *performance case*, which is to document all the reasoning and arguments used to demonstrate that the *performance objectives* (and *performance targets*) will be met.

See also: section 3.2 on page 32.

1.5.12 What are the resulting updates to current transition roadmaps and plans?

Any change to a *transition roadmap* may have implications for other *transition roadmaps* (neighboring *regions* or at a different *planning level*), and/or require a (partial) re-work of existing *research* and *implementation plans*. This needs to be addressed at this stage in the *performance based transition approach*.

See also: section 3.2.2.3 on page 34.

1.6 Glossary of terms

The following terms are used in this document with a specific meaning, which is explained below.

Air traffic management (ATM)	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 (Doc 9854, section 1.1 and Appendix B refer).[2]
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*. (Doc 9854, Appendix A, lists and describes the various members comprising the *ATM community,* e.g. States, ATM service providers, airspace users and the ATM support industry.)

[2] 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 and in Doc 9854.

ATM community expectation	What members of the *ATM community* expect from ATM, in high level qualitative *performance* terms. These expectations are listed in Doc 9854, Appendix D and have been assigned to *Key Performance Areas (KPA)*. (see 1.5.1 and 2.2.1)
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 (Doc 9854, Appendix B refers).
Baseline performance	The *performance* of the *baseline system* during the *baseline period*. (see 1.5.7 and 2.3.1)
Baseline period	An initial (one year) period, for which performance data is available, which can be used as a reference.
Baseline system	The *ATM system* (including a given *traffic pattern* and *volume*) as it was during the *baseline period*. The *baseline system* is used as the reference against which to compare *operational improvements* and *performance* enhancements. (see 2.3.1)
Deployment	The *phase* of an *operational improvement* or *enabler* during which it enters into service (potentially in a progressive way) and starts delivering benefits (Figure 1 and Figure 9 refer).
Development	The *life cycle phase* of an *operational improvement* or *enabler* during which it is transformed from *research* results into ATM changes which are ready for *deployment*. (Figure 1 and Figure 9 refer).
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* (Doc 9854, Appendix B and this document section 3.1.3 refer).
Global ATM Operational Concept	The global air traffic management (ATM) operational concept presents the ICAO vision of an integrated, harmonized and globally interoperable *ATM system*. The planning horizon is up to and beyond 2025 (Doc 9854, section 1.1

refers).

Global level	The highest of the three *planning levels*. The *global level* is responsible for looking after the network effect of *regional* planning activities (4.1 refers).
Implementation	The combination of *development* and *deployment* of an *operational improvement* or *enabler* (Figure 1 and Figure 9 refer).
Implementation plan	An *implementation plan* has a time horizon of typically five years. It is derived from the early (*short term*) parts of a *transition roadmap*. It lays out a detailed set of *implementation* focused actions — including their timing — for all involved members of the *ATM communit*. (1.3, Figure 1, 3.2.1 and Figure 9 refer).
Implementation planning	The process of developing and updating *implementation plans*. The process is usually repeated on an annual basis (1.4 refers).
Key Performance Area (KPA)	The *ATM community expectations* fall into eleven categories, called *Key Performance Areas (KPA).* These are (in alphabetical order): Access and Equity, Capacity, Cost Effectiveness, Efficiency, Environment, Flexibility, Global Interoperability, Participation by the *ATM community*, Predictability, Safety, and Security (1.5.1 and 2.2.1 refer).
Life cycle phase	The life cycle of an *operational improvement* includes phases such as *research*, *development*, and *deployment* (see also the term *implementation* as well as Figure 1 and Figure 9).
Local level	The lowest of the three *planning levels*. The *local level* corresponds to planning activities of individual members of the *ATM community* (4.1 refers).
Long term	The third *transition phase* of a *transition roadmap*. While not precisely delineated along the time axis, it typically covers a period from ten to twenty years into the future (3.2.3 refers).
Medium term	The second *transition phase* of a *transition roadmap*. While not precisely delineated along the time axis, it typically covers a period from five to ten years into the future (3.2.3 refers).

Operational improvement (OI)	*Operational improvements* are changes to the *ATM system* that are on the transition path towards the *Global ATM Operational Concept* and result in a direct *performance* enhancement. An *operational improvement* is a set of elementary changes which are intended to be implemented together to deliver performance. An *operational improvement* is a transition step in a *transition roadmap* (1.5.10 and 3.1 refer).
Performance	ATM *performance* is a measure of how well the *ATM system* satisfies the *ATM community expectations*. In each of the *Key Performance Areas (KPA)*, *performance* is measured at the level of individual *performance objectives*, using *performance indicators* (chapter 2 refers).
Performance assessment	The assessment of past, current and/or planned *performance*. The process of assessing past and current *performance* is called *performance review*. *Planned performance* is assessed during the *research* and *development* phases of the life cycle, using *validation* techniques. (1.5.7, 2.3.1 and 2.3.2 refer).
Performance based transition approach	A method for *transition planning*, in which planning choices are justified in advance by a thorough analysis of anticipated *performance* needs and achievements (1.1 refers).
Performance case	The documentation that contains all the reasoning and arguments used to demonstrate that the *performance objectives* (and *performance targets*) will be met. 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 (1.5.11, 2.1 and 2.3.2.2 refer).
Performance gap	The shortfall between a *performance indicator* value and its *performance target* is referred to as a *performance gap* for a particular *performance objective*. The existence of (anticipated) *performance gaps* is the trigger for introducing additional *operational improvements* via the modification of current *transition roadmaps* and *plans* (1.5.8 and 2.4 refer).
Performance indicator	*Performance indicators* are defined in order to quantify the degree to which *performance*

objectives are being and should be met. When describing *performance indicators*, one must define what and how measurements will be obtained (through *supporting metrics*) and combined to produce the indicator (1.5.3 and 2.2.3 refer).

Performance management	The process of defining *performance objectives*, *performance indicators* and *performance targets.* In addition it includes *performance monitoring*, and the identification of *performance gaps* (1.2 and chapter 2 refer).
Performance monitoring	The process of collecting *performance* data, as required, for calculating the values of *performance indicators*. The aim is to monitor how well *performance objectives* are met (2.3.1 refers).
Performance objective	The *ATM community expectation* embodied by each *Key Performance Area* will be met by pursuing more specific *performance objectives*. *Performance objectives* are expressed in qualitative terms, and include a desired or required trend for a *performance indicator* (e.g. reduce the cost per kilometre flown) while not yet expressing the *performance objective* in numeric terms (this is done as part of *performance target* setting). Care has to be taken to ensure that the agreed *performance objectives* are "SMART" — (specific, measurable, achievable, relevant and timely) (1.5.2 and 2.2.2 refer).
Performance review	The assessment of past and current *performance*, using measured data obtained via *performance monitoring* (2.4.3 refers).
Performance target	*Performance targets* are the values set on *performance indicators* that need to be reached or exceeded to consider a *performance objective* as being fully achieved. Note that *performance targets* can be set as a function of time (e.g. to plan year-on-year improvement); they can also vary by geographic area (1.5.4 and 2.2.5 refer).
Planned performance	The future *performance* associated with a *transition roadmap*. *Planned performance* is assessed during the *research* and *development* phases of the life cycle, using *validation* techniques (see also *performance assessment*, as well as 1.5.7 and 2.3.2).

Planning cycle	The interval at which the *transition planning* process is repeated to take into account changing forecasts, up-to-date information on *implementation* progress, new *performance assessment*, changed performance expectations and policies (resulting in revised *performance targets*), and any other relevant change. Typically five years for *transition roadmaps*, and one year for *research* and *implementation plans*. (1.4 and 4.5 refer).
Planning level	*Transition planning* takes place at different levels called *planning levels*. These are the *global level*, *regional level* and *local level* (4.1 refers).
Regional level	The intermediate of the three *planning levels*. At *regional level*, *ATM community* members have agreed to evolve the *ATM system* in accordance with a common *transition plan*. Operating environments and priorities may be different. *Regional performance targets* will be defined. The *regional level* is defined by a division of the world into homogeneous regions and major traffic flows with similar characteristics, and a common ATM interest in terms of *performance* and *transition planning*. The *regional level* is responsible for looking after the network effect of *local* planning activities. (4.1 refers).
Research	The *life cycle phase* of an *operational improvement* during which it is progressively transformed from a concept into a refined and validated ATM change which is ready for *development* (and can be included in *implementation planning*) (Figure 1 and Figure 9 refer).
Research plan	A *research plan* has a time horizon of typically five years. It is derived from the *medium term* and *long term* parts of a *transition roadmap*. It lays out a detailed set of *research* focused actions — including their timing — for all involved members of the *ATM community* (1.3, Figure 1 and Figure 9 refer).
Research planning	The process of developing and updating *research plans*. The process is usually repeated on an annual basis.
Short term	The first *transition phase* of a *transition roadmap*. It covers the period for which *implementation*

	plans have been established, which typically corresponds to a five year time horizon (3.2.3 refers).
Supporting metric	*Supporting metrics* determine which data needs to be collected to calculate values for the *performance indicators* (1.5.3 and 2.2.3 refer).
Traffic pattern	The distribution of the total annual *traffic volume* in geographic terms (airport-pair flows and route-dependent overflights), time distribution (seasonal, weekly, daily, hourly fluctuations) and aircraft type mix (1.5.4 and 2.2.4 refer).
Traffic volume	The amount of air traffic, usually expressed in terms of number of flights or movements, but sometimes also in terms of distance flown or controlled, or flight hours flown or controlled (1.5.4 and 2.2.4 refer).
Transition	The sequence of *deployments* that constitute the transition from the current *ATM system* to the future *ATM system* envisaged in the *Global ATM Operational Concept*. The transition is documented in the *transition roadmap* (1.3 refers).
Transition phase	The *transition roadmap* is typically divided into three *transition phases*: *short term*, *medium term* and *long term* (3.2.3 refers).
Transition plan	A set of aligned, consistent plans and roadmaps, consisting of: a *transition roadmap*, the *research plan* and the *implementation plan* (1.4 and 4.5 refer).
Transition planning	The process of developing and updating the *transition plan*. It consists of *transition roadmap* development, *research planning* and *implementation planning* (1.4 and 4.5 refer).
Transition planning step	The *performance based transition approach* defines five steps which must be executed during a single iteration of the *transition planning* process. These steps are: (1) translate *ATM community expectations* into quantified *performance targets*; (2) conduct *performance assessment* and use *performance targets* to identified current and anticipated *performance gaps*; (3) update *transition roadmaps* and *plans* to mitigate identified *performance gaps*; (4) analyze

	steps 1-3 to generate lessons learned; and (5) maintain the guidance material and the overall planning process itself (1.5 and 4.5 refer).
Transition roadmap	The *transition roadmap* covers a twenty year rolling time period. It contains a sequence of *operational improvement deployments,* which is suitable for transitioning the current *ATM system* to the future *ATM system* envisaged in the *Global ATM Operational Concept*, while meeting the performance requirements as documented by the *performance objectives* and *performance targets* (1.3, 1.5.11 and 3.2 refer).
Validation	The process of determining that an *operational improvement* or *enabler* (and by extension the entire *transition roadmap*) functions as intended, and of developing the *performance case* which provides sufficient confidence that the *operational improvement / enabler / transition roadmap* will be able to meet the performance requirements as documented by the *performance objectives* and *performance targets* (1.5.7, 2.3.2, 2.4.3, 3.1.2 and 3.2.2.2 refer).

2 Measuring and Assessing Performance

2.1 Introduction

The performance based approach rests on the basic principle that the *ATM community expectations* can best be satisfied by quantifying these expectations into a set of agreed *performance targets* (which are periodically adjusted), then using these *performance targets* as the yardstick to introduce ATM performance improvements in a controlled way, and last but not least using the *performance targets* to justify these improvements (including them in system-wide safety, business and environment cases, or – more generally – a *performance case*).

For this approach to work, a performance-based *ATM System* requires performance measurement and assessment. While the process is iterative, several steps can be isolated (steps 1 and 2, as defined in section 1.5; numbers in parenthesis refer to boxes in Figure 2).

- Step 1: translate *ATM community expectations* into quantified *performance targets*
  - **(1) Identification of ATM community expectations and corresponding Key Performance Areas (KPA)** – Starting with the set of general expectations listed in Doc 9854, key areas of performance have been identified which serve as the general framework for classifying performance needs and improvements. All planners are expected to use this standardized set of *KPAs*.
  - **(2) Reaching agreement on performance objectives** – The *ATM community expectation* embodied by each *Key Performance Area* is to be met by pursuing a choice of more specific *performance objectives* in each planning region, which are adapted to the challenges facing the region. The selected *performance objectives* will serve as the *regional* and *local* drivers for performance improvement.
  - **(3) Reaching agreement on performance measurement methods** – Quantitative *performance indicators* must be defined for each *performance objective*, together with a description of the *supporting metrics*, guidance on how to collect the data, and the computation required for obtaining the *performance indicators*.
  - **(4) Reaching agreement on the expected traffic evolution** – For certain *performance objectives* (e.g. in the capacity area), the *performance targets* are dependent on the traffic/demand forecast.
  - **(5) Setting performance targets** – A performance-based *ATM system* seeks to attain *performance objectives* by setting specific *performance targets* on the *performance indicators*. These *performance targets* must be selected such that reaching a *performance target* corresponds to meeting a *performance objective*. *Performance targets* must also be validated to ensure that they are feasible and not arbitrary.

  A decision-making / policy-making process needs to be in place to collaboratively agree on *performance objectives*, *performance indicators* and the values of *performance targets* at the *local*, *regional* and — where required — the *global level*.

- Step 2: conduct *performance assessment* and use *performance targets* to identify current and anticipated *performance gaps*
    - **(7) Measurement of performance** – Measurement of the actual performance of the *ATM system* must be undertaken. This measurement establishes the level of performance of the system as measured by the *performance indicators* previously established.
    - **(6-7) Prediction of planned ATM system performance** – Anticipated changes in traffic levels, fleet equipment, procedures, and infrastructure modernization can all lead to variation in performance over time. Estimates of the future evolution of *performance indicators* must be undertaken to pre-emptively determine if additional *ATM system* improvements are required to meet the established *performance targets*.
    - **(8) Identification of current and anticipated performance gaps** – The shortfall between a *performance indicator* and its *performance target* is referred to as a *performance gap* for a particular *performance objective*. The existence of (anticipated) *performance gaps* is the trigger for introducing additional *operational improvements* via the modification of current *transition roadmaps* and plans.

2.2 Translate ATM community expectations into quantified performance targets

The process of translating *ATM community expectations* into quantified *performance targets* is illustrated in Figure 3. *Key Performance Areas* (section 2.2.1 refers) map into *performance objectives*; the expression of those *performance objectives* maps into quantitative *performance indicators* which have set *performance targets*.

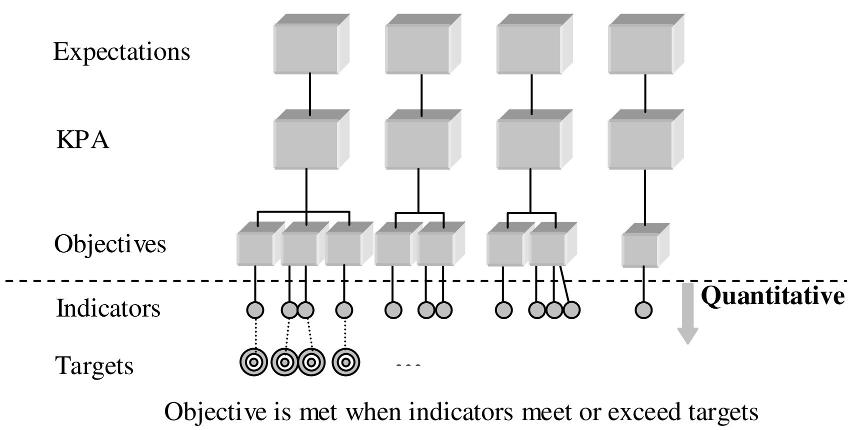

Figure 3 Mapping of ATM community expectations to performance targets

2.2.1 What are ATM community expectations and Key Performance Areas (KPA)?

1

What are the ATM community expectations?

The *ATM System* seeks to meet diverse expectations in terms of service delivery. These expectations are detailed in Appendix D of Doc 9854 and constitute the starting point for ATM *performance objectives*. For *performance management* purposes, it is considered that each of these expectations corresponds to a single *Key Performance Area* (*KPA*) as shown below.

- KPA 01 – Access and Equity
- KPA 02 – Capacity
- KPA 03 – Cost Effectiveness
- KPA 04 – Efficiency
- KPA 05 – Environment
- KPA 06 – Flexibility
- KPA 07 – Global Interoperability
- KPA 08 – Participation by the *ATM Community*
- KPA 09 – Predictability
- KPA 10 – Safety
- KPA 11 – Security

These *KPAs* serve as the general framework for classifying performance needs and improvements. All planners are expected to use this standardized set of *KPAs*.

2.2.2 How to determine performance objectives?

2

What are the performance objectives?

The *ATM community expectation* embodied by each *Key Performance Area* is to be met by pursuing a choice of more specific *performance objectives* in each planning region, which are adapted to the challenges facing the region. The selected *performance objectives* will serve as the *regional* and *local* drivers for performance improvement.

Performance objectives are precisely scoped (i.e. which part of the *ATM system* is the *performance objective* for), express performance in terms of specific aviation objects, events and quantities, and include a desired or required trend for a *performance indicator* (e.g., reduce the ATM cost per kilometre flown) while not yet expressing the achievement of the *performance objective* in numeric terms (this is done as part of *performance target* setting). For example, "improve on-time arrival of flights throughout a particular *regional* or *local* planning area" could be one of the *performance objectives* of the Efficiency *KPA*.

The agreed *performance objectives* must be "SMART":

- **Specific** – The *performance objective* must be expressed in terms of the objects and events that represent air traffic and its operational environment.
- **Measurable** – It must be associated with one or more clearly defined *performance indicators*, and it must be possible and affordable to establish the required data collection processes and to solve information disclosure issues.
- **Achievable** – *Performance objectives* can be challenging, but must realistically consider the public environment, timing and available resources.
- **Relevant** – *Performance objectives* should only be defined where there are anticipated performance problems and opportunities related to *ATM community expectations*.
- **Timely** – The *performance objective* must be achievable in a timely fashion so as to contribute to the *ATM community expectations*.

2.2.3 How to measure progress towards a performance objective?

3

How to measure performance?

Management of performance will be done at the level of specific *performance objectives*. *Performance indicators* are defined in order to quantify the degree to which *performance objectives* are being met. When describing *performance indicators*, one must define what and how measurements will be obtained and combined to produce the *performance indicator*. *Performance indicators* should be quantitative, robust and outward looking, convey meaningful information about process performance for a given *performance objective* and be suitable to trigger improvement and change.

For the example "improve on-time arrival…" *performance objective* of section 2.2.2, the *performance indicator* could be "average arrival delay per flight in planning area X". To calculate this *performance indicator*, one must obtain data on the scheduled and actual arrival times of all flights in planning area X. From this, one can determine the total arrival delay (a *supporting metric*), and divide that value by the number of arrivals (another *supporting metric*) to calculate the desired *performance indicator*.

Performance indicators intended for use at *regional* and *global level* should be standardized so as to facilitate consistency of data collection at the *local level*.

2.2.4 Traffic forecasting

2.2.4.1 Why forecast?

4

What is the expected traffic evolution?

A shared and consistent understanding of the future is one of the pillars for setting *performance targets* as well as assessing the performance impact of existing plans and *transition roadmaps*.

Forecasts are used as input for some of the *performance targets*. For example, the capacity target for an ATM operational environment (e.g. en-route centre, volume of airspace) is dependent on the forecasted traffic.

2.2.4.2 What needs to be in a forecast?

Forecasting should produce the information necessary to gain a better understanding of the characteristics of the traffic — that is, of the demand. This more qualitative view is an important input for planning *ATM systems*.

For example, forecasts containing just traffic and aircraft size based on number of seats are not sufficient to investigate the performance impact of improvements relying on airborne equipage. Analysis of future performance may also require information on fleet mix, specific aircraft equipage levels, engine types, and demand (at the passenger / cargo level). For setting *performance targets* on the environment it could be important to have a forecast on kilometres (km) or nautical miles (nm) flown per engine type in addition to a forecast on the total km/nm flown.

Existing forecasts probably need to be enhanced to incorporate such additional information.

2.2.4.3 Do we need different types of forecast?

Forecasts can have different time horizons (e.g. long term 20+ years, short term one year) and scope/forecasted information (e.g. number of movements, passenger kilometres, fleet).

The scope and time horizon of the traffic forecast should be driven by the requirements for setting *performance targets*.

For example planning of next year's capacity for an en-route centre requires a more detailed and accurate forecast than is required for developing a region-wide strategic *transition roadmap* for the next twenty years. Dependent on their time horizons, forecasts use different forecasting methods. A forecast for next year is typically made using statistical approaches whereas a *long term* forecast uses econometric approaches and forecast scenarios.

2.2.4.4 Does performance affect the forecast?

The *ATM system* will react to changes in performance; thus, performance changes may alter the forecast. For example, airport capacity will act as a constraint on traffic demand and may result in migration to larger aircraft and/or increased demand at nearby uncongested airports. The provision of improved performance for early-adopters of an airborne technology may increase the equipage rate for that technology. This illustrates that the *performance assessment* and the forecast scenarios should be verified for consistency and may require iteration.

2.2.4.5 Need for iterative forecasts

Consistency between regions and localities may require an iterative process. Certain decisions by one region or locality may be reached only after performance has been assessed. However, these decisions may substantially impact the forecasts required by adjacent areas. For example, mandatory requirements for equipage or other changes that significantly alter the cost structure in one region or locality might have a significant impact on neighbours. At a minimum, a cyclical and synchronized performance planning process will allow these effects to be captured.

2.2.4.6 Cooperation in developing forecasts

Developing a forecast is also a process to achieve a shared understanding of the future with *ATM community* members. This consensus is essential since it is the basis for identifying needs and agreeing plans.

Not only should the forecast itself be developed in a collaborative manner, to enhance credibility of the forecast, but the forecasting approach and method also need to be subject of collaboration between community members.

The development of a *long term* forecast typically starts with identifying and agreeing the forecast scenarios. Each scenario represents a consistent possible future specified in terms of values for the input parameters of the forecast (e.g. economic growth, oil price, development of tourism etc.). During this phase it is important to capture all future scenarios believed to be possible.

A forecast will normally include three or four different input scenarios (sets of input assumptions about external factors), resulting in a corresponding number of traffic forecasts. As part of the cooperation, it is important that *ATM community* members agree to use the same forecasting scenario as the basis for setting *performance targets* and estimating future performance.

2.2.5 Performance targets – how one knows performance objectives are attained

5

What are the performance targets?

Performance targets are closely associated with *performance indicators*: they represent the values of *performance indicators* that need to be reached or exceeded to consider a *performance objective* as being fully achieved. Note that *performance* *targets* can be set as a function of time (e.g. to plan year-on-year improvement); they can also vary by geographic area.

A decision-making / policy-making process needs to be in place to collaboratively agree on *performance objectives*, *performance indicators* and the values of *performance targets* at the *local*, *regional* and — where required — the *global level*.

2.2.6 How to set valid performance targets?

Performance targets are not set in an arbitrary manner. For certain *performance objectives* (e.g. in the capacity area), the *performance targets* are dependent on the traffic/demand forecast. Knowledge gained through the baseline activities and modelling of future scenarios should provide guidance as to both current and achievable values for *performance indicators*. In particular for *short-term* performance improvements, *performance targets* should reflect what is possible in the time period. Over the long run, *performance targets* can push the envelope of what is currently possible.

2.2.7 Learning from your neighbours

Through benchmarking and the analysis of best practices, localities and Regions may be able to learn from other areas what achievable *performance indicator* values are, and what the combination of practices is which is required to obtain those levels of performance. The benchmarking activity allows feasible *performance targets* to be set, based upon experience in other areas. While these practices may not be directly transferable, understanding the relationship between performance and practices provides guidance that is useful as a supplement to performance modelling or when modelling is not feasible.

2.3 Measuring and assessing performance

2.3.1 Assess current performance

7

What is the current ATM performance?

At regular intervals, the performance of the actual system must be established through measurement of operational data and calculation of *performance indicators*. Measurement of current performance is used for the following purposes:

- To establish an initial performance level (i.e. a baseline), and
- To track actual progress towards meeting *performance objectives* by comparing the *performance indicators* with set *performance targets*.

2.3.1.1 When and how to assess current performance?

Prior to focusing on the future performance of the *ATM system*, one must first determine the performance of the current *ATM system*. This process is referred to as assessing the *baseline performance* and allows one to establish the level of performance of the current system in each *Key Performance Area* and for each *performance objective* through the relevant *performance indicators*. Once *performance indicators* have been defined and mapped to each *performance objective* and *KPA*, the assessment of *baseline performance* involves the collection of required data during the *baseline period*, and the calculation of each *performance indicator*.

2.3.1.2 Data quality and availability

Many *ATM community* members can be involved in the performance data reporting process with each member having to justify the effort. The data reporting process should be harmonized between these organizations with common definitions, and reporting requirements. Furthermore, legal, organizational and managerial impediments may also exist.

Mechanisms should be in place to ensure that confidentiality is preserved such that sensitive data is not used inappropriately.

Data quality will impact which *performance indicators* can be confidently obtained and may negatively affect the performance-based approach. Consistency in data quality is also required across multiple dimensions (e.g. time, space, type of flights).

Just as data quality should be consistent across multiple dimensions, data should also be available across these dimensions. This can be difficult to achieve.

Performance monitoring is an ongoing evolving process. Comparison of forecasts to actual performance and tracking tasks all require consistency and stability in data. Data that is collected today may be required for a different purpose in the future. It is therefore critical that data collection efforts be forward-looking and precisely described.

Initial *performance indicators* may be constrained by the available data. While these may provide reasonable starting points for transition to a performance-based *ATM system*, future data requirements should be planned to ensure that the requisite data will be available.

2.3.1.3 Using the baseline to understand performance

Once the *baseline performance* has been established, one can begin to quantify the understanding of performance. For example, each *KPA* may have *performance objectives* that the *ATM community* agrees are not being met. Through the application of quantitative *performance indicators*, one begins to understand the actual *performance indicator* levels at which *performance objectives* are or are not being met, and consequently, what appropriate *performance target* levels are. For example, if the *ATM community* agrees that ATM-induced delays are a problem, only after ATM-induced delays are measured can one begin to understand the level of delays that is unacceptable.

2.3.1.4 Understanding inter-relationships

Determination of the *baseline performance* will involve multiple *performance objectives* within *KPAs* and across multiple *KPAs*. Prior to embarking on performance improvement, it is important to develop an understanding of the inter-relationships between different *performance objectives* within a *KPA*, and between different *KPAs*. These interdependencies can allow performance improvement in one area through a trade-off in performance with another area. Alternatively, interdependencies can lead to adverse consequences when trying to improve one area. Some examples are listed below.

- Within the efficiency *KPA*, trades can be made between fuel and time costs. Improvements in only one measure may not reflect improvements in overall efficiency.
- Within the environment *KPA*, certain noise abatement procedures may decrease noise at the expense of increasing emissions.
- Between the environment *KPA* and the capacity *KPA*, continuous descent approach procedures may provide improvements in both noise and emissions at the expense of capacity.
- The ability of airspace users to modify flight trajectories or arrival and departure times will favourably impact the flexibility *KPA*, but may adversely impact the capacity *KPA*.
- While a positive correlation exists between capacity and efficiency, as measured by delay, consideration of cost efficiency is required.

2.3.2 Validating planned performance

7 What is the planned ATM performance?

Planned performance is the performance achieved if a given set of plans and *transition roadmaps* is implemented. *Planned performance* needs to be assessed through *validation* activities. The main objective of *validation* is to reduce uncertainties in critical decision areas such as performance. It is an essential part of the performance planning process, as it allows the evaluation of future performance under circumstances such as:

- No *ATM system* improvements (do nothing scenario),
- Cancellation of planned improvements,
- *Implementation* of already planned *ATM system* improvements, and
- *Implementation* of additional *ATM system* improvements beyond what is currently planned (assessment of the performance impact of proposed updates to plans and *transition roadmaps*).

2.3.2.1 What assumptions to use for the future?

6 What are the current roadmaps and plans?

Estimating the future performance of the *ATM system* is an essential subject of ongoing *research* and *development* and should be organized in such a way that it provides input to the planning process. Two possible sets of assumptions commonly used are as follows:

- The "**do nothing**" case – this set of assumptions assumes that the *ATM system* will remain as it is today. However, externally-driven changes (e.g. growth in traffic, changes in fleet composition) will drive changes in performance.
- The "**planned improvements**" case – this assumes that the *ATM system* will change according to a specified plan already in place. Changes in performance will be affected by the prior external changes, in concert with all *ATM system* changes that are already planned. Note that this case may still not meet *performance targets* if situations have changed since the improvements were planned.

2.3.2.2 What are commonly used validation methods?

Methods for estimating the performance of the future *ATM system* are varied and include analytical/statistical methods, system dynamics, influence analysis, fast-time and real-time simulation, and prototyping. Modelling of interactions between *local* and *regional* effects may be required for certain *performance cases* as one may not always be able to isolate ATM performance to one locality.

2.3.2.3 How to deal with uncertainty?

7

What is the planned ATM performance?

One aspect that must be considered is uncertainty. Uncertainty is present not only in the traffic forecast, but also in the *validation* results. Therefore the estimated future values of *performance indicators* are subject to uncertainty. Methods for dealing with this uncertainty include:

- **Probabilistic estimation of the performance outcome** of future improvements. This can be used in models which describe how uncertainty propagates through the chain of related *performance indicators*, to allow sensitivity analysis.
- **Real measurement data on past and current performance**, as improvements are deployed. This provides a control mechanism to track progress and re-evaluate whether improvements are sufficient or excessive to meet *performance targets*.

2.4 Identify and diagnose performance gaps

2.4.1 What is a performance gap?

8

What are the current and anticipated performance gaps and their reasons?

The term *performance gap* is used to denote a current or anticipated mismatch between the current or *planned performance* and the *performance target*. This is illustrated in Figure 4.

In this example, the capacity target increases gradually — in line with the traffic forecast — and the planned capacity increases in a stepwise fashion. As can be seen in the figure, a *performance gap* exists for those years where available capacity is lower than required capacity.

The (anticipated) existence of a *performance gap* indicates that a *performance objective* is not or will not be fully achieved, and by consequence that the *ATM community expectations* in one or more *Key Performance Areas* will not be met to the extent desired.

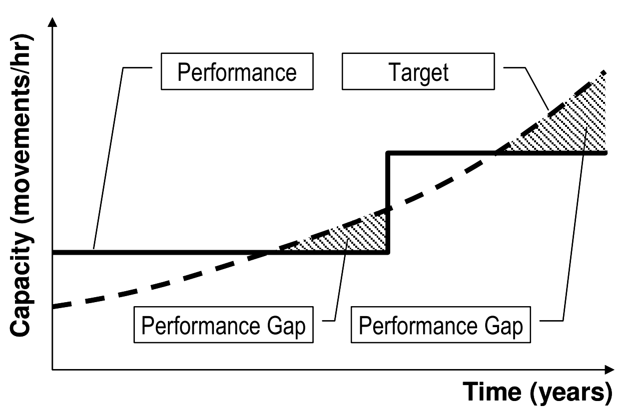

Figure 4 What is a performance gap?

The opposite is also possible: performance (temporarily) exceeding the *performance target*. This is rarely seen as a problem, as long as other *performance targets* (e.g. cost effectiveness) are still met. In many cases there are good reasons for having 'spare' performance in the system: e.g. to be ready for future more challenging *performance targets*. A typical example is the presence of spare capacity in a traffic growth scenario.

Gaps are calculated at the level of *performance indicators*, but need to be analyzed at a higher level (*performance objectives* and *Key Performance Areas*) to determine where and when improvements are necessary.

2.4.2 What are the possible reasons for performance gaps?

Normally, *transition roadmaps* and plans have been adapted during the previous *planning cycle* to mitigate all *performance gaps*. If — as part of the current planning iteration — new gaps are discovered, an analysis should be conducted to understand the underlying reasons for these new gaps. Such an understanding helps to choose the most appropriate approach for closing the gaps.

The possible causes include the following:

2.4.2.1 Performance targets have been changed

When more challenging *performance targets* are applied or traffic demand is higher than previously forecasted, current performance levels and/or the previously agreed performance enhancement profile may not be sufficient any more. An example of this is shown in Figure 5.

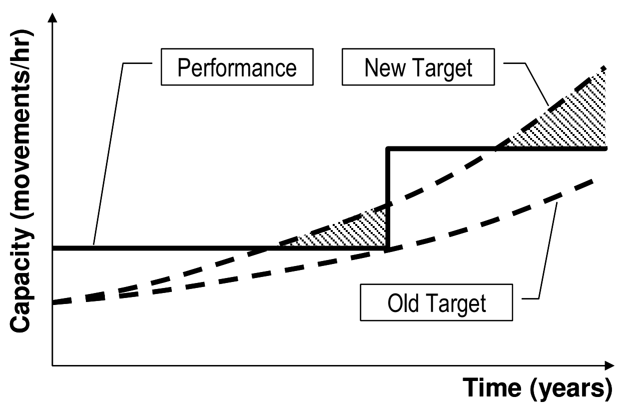

Figure 5 Effect of more challenging performance targets

2.4.2.2 Revised traffic forecast negatively affects performance levels

The opposite is also possible: *performance targets* which remain the same over time, but performance is expected to be less favourable due to a revised (more challenging) traffic forecast, again leading to *performance gaps*.

In the example of Figure 6, safety performance is expressed in terms of the number of ATM related accidents per year. Lower values represent better performance. The *performance objective* stipulates that the annual number of accidents should not increase, even in the face of traffic growth (*performance target* remains constant through time). The presently foreseen *operational improvements* are sufficient to keep the performance at a constant level, well below the *performance target*. In the example, a revised (increased) forecast without adapted *operational improvements* is expected to lead to an increased number of ATM related accidents, eventually resulting in a *performance gap*.

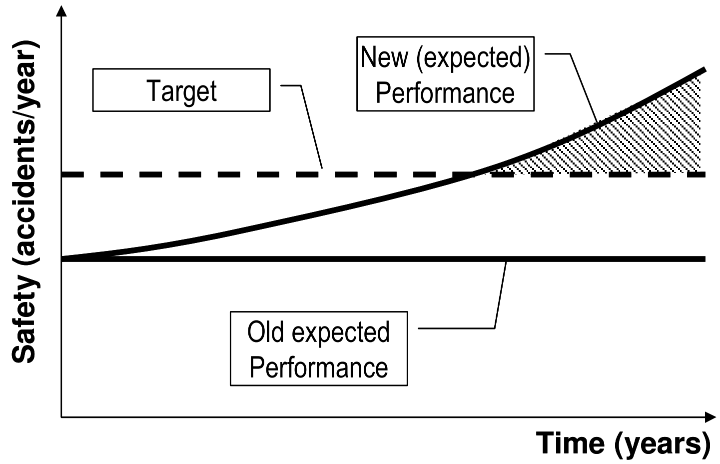

Figure 6 Effect of changing traffic evolution

2.4.2.3 Implementation not according to plan

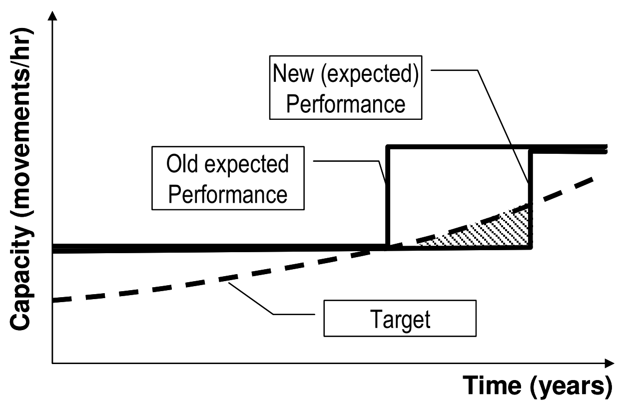

Figure 7 Effect of delayed implementation

When plans do not get implemented as foreseen (*implementation* is delayed or plans are only partially being implemented), performance enhancements will be shifted into the future. As shown in Figure 7, this may result in performance falling behind *performance targets*.

The first time the process is applied, there may not yet be a plan. In that case, the *performance gaps* indicate what would happen in a 'do nothing' planning scenario.

Comparison against a 'do nothing' scenario may also be useful to demonstrate the added value of a given *transition roadmap* or plan against a baseline situation.

2.4.2.4 Operational improvements deliver less than expected performance benefits

When performance improvement estimates associated with *transition roadmaps* and plans are revised downwards (see Figure 8), the resulting benefits may not be sufficient to cover the performance needs.

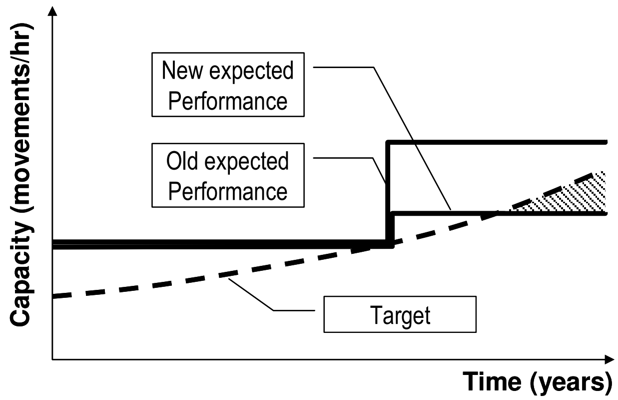

Figure 8 Effect of revised benefit estimates

2.4.3 Performance assessment/review in practice

8

What are the current and anticipated performance gaps and their reasons?

The task of identifying and diagnosing *performance gaps* corresponds to answering question 8 (What are the current and anticipated performance gaps and their reasons?) that was introduced in paragraph 1.5.8.

This type of activity is called *performance assessment* or *performance review* (latter term used when analyzing past and current performance). It is a data-oriented analysis activity, which according to Figure 2 is based on the following inputs:

- output from box 7: current and anticipated values for each of the *performance indicators*, under certain assumptions (forecasting scenarios and existing *transition roadmaps* and plans)
- output from box 5: the latest version of the agreed *performance targets*.

In principle, the output of this activity is just a list of *performance gaps* and their causes. In practice, the scope of the activity is often interpreted as being much wider and includes the offering of recommendations to mitigate the gaps.

For the purpose of organizing *performance assessment/review*, the task can be broken down into four separate activities:

- Data publication
- Data analysis
- Formulation of conclusions
- Formulation of recommendations.

2.4.3.1 Data publication

Performance assessment/review can start once the required data (*performance targets* and current/anticipated values for *performance indicators*) are available. The first activity in this process is data publication.

With proper *ATM community* participation in place, ATM performance will be evaluated by two different groups:

- Members of the *ATM community* at large
- Analysts from designated ATM *performance review* organizations

Each group has its own specific need for access to ATM performance data, which should be satisfied by appropriate data publication means.

The *ATM community* at large has a general interest in ATM performance. Even those not directly involved in planning activities want to see executive level, quality controlled data and draw their own conclusions. From there comes the need to make certain performance data publicly available, in the interest of transparency. It is important to avoid the perception that there is something secret about ATM performance. A capability is therefore required which enables members of the *ATM community* to monitor the current situation against the *performance targets*, and to provide them with the trends and the big picture. This need is generally satisfied by publishing high level *performance indicator* dashboards. These dashboards are periodically updated, and generally allow limited or no interactivity (customization by the user).

In addition, analysts from designated ATM *performance review* organizations are tasked with gaining an in-depth understanding of ATM performance, and finding causes and effects. Their work is an integral part of the *performance management* process described in chapter 2. Their data needs are best satisfied by publishing selected data in *performance assessment* databases which are designed to suit the analysts' needs. These databases should allow high levels of interactivity (querying and analysis).

2.4.3.2 Data analysis

At the data analysis stage, the *performance assessment/review* organization should ensure that the data is already quality checked. Rather than struggling with data quality issues, analysts should be able to focus on their main task: *performance assessment/review*.

Analysts will need to compare *performance indicators* against *performance targets*, identify performance evolution trends, analyze historical evolution of performance, and find relationships (correlations) between *performance indicators*, *supporting metrics* etc.

They do this with the aim of gaining better insight into past, current and future ATM performance. They will have to look at the big picture (annual totals and averages, *performance indicators* summarized at the level of planning region) but also drill down to very detailed levels to find the causes of *performance gaps* and the reasons for trade-offs. As a side-effect of data analysis, they should be able to formulate *performance objectives*, define new *performance indicators* and identify data needs.

Analysts, as well as decision-makers, will benefit from using well-established cause and effect analysis methodologies/models that facilitate the identification of the main drivers impacting the performance of the system.

2.4.3.3 Formulation of conclusions

After completing the data analysis, analysts are expected to document the insight they have gained by formulating conclusions for each *Key Performance Area*. Normally, these conclusions contain an assessment of the sufficiency of current and expected future performance, for each *performance objective*. Alternatively, a conclusion could be that the available data is insufficient for meaningful *performance assessment/review*.

Typically, the conclusions are published in a *performance review* report.

2.4.3.4 Formulation of recommendations

An integral part of the *performance assessment/review* process is the formulation of recommendations. These should be derived from the conclusions, and be also included in the *performance review* report.

Recommendations should focus on how to meet *ATM community expectations* through agreed *performance objectives*, *performance indicators* and *performance targets*. When evaluation indicates inconsistency between *ATM community expectations* and *performance objectives*, *performance indicators* and *performance targets*, recommendations may include:

- the need to set or change *performance objectives*
- the need to (re-)define *performance indicators*
- the need to set or change *performance targets*

Recommendations will also fall more typically into the following categories (non-exhaustive list):

- Related to the need to improve performance data collection
- Suggested *operational improvements* related to identified *performance gaps*
- Recommendations of an organizational nature (set up task force, define action plan etc.) with a view to actually starting the implementation of the above recommendations.

2.4.3.5 Positioning of performance assessment/review within the overall process

This document recommends a sufficient integration of the *performance assessment/review* activity into the overall performance planning process, to ensure that the conclusions and recommendations serve as a direct input to box 11 of the *performance based transition approach* outlined in Figure 2.

At the same time, *performance assessment/review* should maintain a certain independence from the other parts of the process, in order to ensure a sufficient level of objectivity and impartiality.

3 Addressing Performance Gaps

Addressing *performance gaps* corresponds to step 3 (update *transition roadmaps* and plans to mitigate identified *performance gaps*) as listed in section 1.5.

3.1 Operational improvements

This section addresses box 10 (What are the available options for operational improvement?) in Figure 2, and the guidance that is to be obtained from box 9 (What is the Global ATM Operational Concept and associated system requirements?).

3.1.1 What are operational improvements?

10

What are the available options for operational improvement?

Operational improvements are changes to the *ATM system* that are on the transition path towards the *Global ATM Operational Concept* (3.1.4 refers) and result in a direct performance enhancement. Because of their need to deliver performance, the elementary changes that make up an *operational improvement* are intended to be implemented together. An *operational improvement* is a transition step in a *transition roadmap*.

By its very nature, an *operational improvement*:

- is associated with a particular 'before' state of the *ATM system* (defines the environment in which the change can be implemented),
- describes the 'after' state of the transition and
- includes an estimate of the corresponding performance improvement.

3.1.2 What is the role of operational improvements in the planning process?

An *operational improvement* is a transition step in a *transition roadmap*; it should therefore be suitable for being developed into a (major) *implementation* project or programme. This will need to be done when the early parts of a *transition roadmap* are elaborated into an *implementation plan*.

The output of box 10 of the *performance based transition approach* in Figure 2 should ensure that a common list of possible *operational improvements* is offered to the planning community to deliver the list of options from which to develop *transition roadmaps* adapted to the specific needs of each region.

Since the various regions of the world develop at different speeds and also may find diverse solutions to similar performance problems, this list of options will essentially consist of two groups of *operational improvements*:

- Mature improvements which have already been implemented in parts of the world, and are considered 'best practice' for similar performance problems and/or for meeting specific *performance objectives*
- Improvements not implemented anywhere yet, but currently in the process of being researched, developed, and/or validated, and considered to be viable candidate solutions for meeting future performance needs

Appendix A of this document provides a number of illustrations of *operational improvements*.

3.1.3 Developing a list of available options for operational improvement

Operational improvements are made possible by technical system, human factor, procedure and institutional *enablers*. These need to be identified and analyzed to understand the feasibility, timing, cost or, in general, the impact of an operational change. The *operational improvements* are developed from different complementary perspectives:

- High level strategy and policy orientations.
- Operational concept/concept of operation describing the operational evolution through time.
- Architecture in which the technical system *enablers* (e.g. flight data processing systems, CNS systems) of the *operational improvements* should fit.
- Baseline ('before' state) from which the *operational improvements* need to be deployed and deliver benefits.
- Feasibility and timing from complementary perspectives defining the feasibility/timing of *developing/deploying* the *enablers* required for the *operational improvement*. Typically this will provide information on earliest availability.
- The safety and human factors assessment is required to have sufficient confidence that the *operational improvement* is feasible from a human factors and safety perspective, and that a first list of issues that need to be addressed during the development life cycle is raised.
- Last but not least: the expected performance enhancement contribution in each of the *Key Performance Areas* should be assessed. More specifically, it should be explicitly specified to which *performance objective(s)* the improvement is targeted, and which *performance indicator(s)* are intended to be influenced.

The *Global Air Navigation Plan for CNS/ATM Systems* (Doc 9750,Global Plan) is one of the sources for developing the list of *operational improvements*. Use can also be made of work undertaken in other planning regions.

In those cases where a list of *operational improvements* was already developed during a previous *planning cycle*, the task consists of updating the list to take the latest developments into account.

3.1.4 Using guidance from the Global ATM Operational Concept and associated system requirements to develop operational improvements

This section explains the role of box 9 of the *performance based transition approach* in Figure 2.

9

What is the Global ATM Operational Concept and associated system requirements?

3.1.4.1 Role of concept and requirements documents

The *operational improvements* that are applied to achieve performance enhancements should be focused to enable the achievement of a common goal, a common vision of ATM. The ICAO vision of an integrated, harmonized and globally interoperable *ATM system* for a planning horizon up to and beyond 2025 can be found in the *Global ATM Operational Concept* (Doc 9854).

This vision and its envisaged performance characteristics is further detailed in a set of system requirements which can be found in the document entitled *ATM System Requirements Supporting the Global Air Traffic Management Concept*.

Together, these documents form the main guidance material for determining the available options for *operational improvement*.

3.1.4.2 Categorization and sequencing of operational improvements

Chapter 2 of the *Global ATM Operational Concept* defines seven operational concept components which can serve as the general categorization framework for *operational improvements*:

- Airspace organization and management (AOM)
- Aerodrome operations (AO)
- Demand and capacity balancing (DCB)
- Traffic synchronization (TS)
- Airspace user operations (AUO)
- Conflict management (CM)
- ATM service delivery management (ATM SDM)

This same structure is also used to group requirements in section 2.4 of the *ATM System Requirements* Document.

In addition to the seven operational concept components, both documents describe the exchange and management of information used by the different processes and services:

- Information services

The list of *operational improvements* should be classified around those eight categories, and should be based on the material in the above mentioned operational concept and requirements documents.

As mentioned in 3.1.3, *operational improvements* should also be categorized according to the *performance objectives* to which they are intended to contribute (while it is recognized that *operational improvements* may also have an adverse impact on certain other *performance objectives*, the main purpose of categorization is to point the *ATM community* towards suitable solutions for given performance problems).

Some *operational improvements* may cut across classification categories — irrespective of whether such categories are derived from the operational concept components, or are the *KPAs* or are the *performance objectives*.

3.2 Building/updating your transition roadmap

This section covers boxes 11 and 12 in Figure 2.

The result of box 11 is a new version of the *transition roadmap* for a particular region.

The *ATM community* will need to modify the current version of the *transition roadmap* (built during the previous *planning cycle*) and re-assess the performance impact of the changes. The resulting new *transition roadmap* is acceptable if it has a realistic potential for mitigating the *performance gaps*.

3.2.1 What is a transition roadmap, and how is it different from a plan?

A *transition roadmap* is a high level representation of the selection of *operational improvements* and their *implementation* sequence, adapted to the needs of a particular planning area (at *regional* or *local level*).

A *transition roadmap* has a long time horizon (typically twenty years) and a low update frequency (typically once every five years).

It is more a driver for the initiation of *research* than for *implementation*. Therefore, in a *transition roadmap*, specifying the sequence of improvements is more important than trying to pinpoint the exact timing of their *deployment*. It is common practice to subdivide the time period covered by a *transition roadmap* into three phases: *short term*, *medium term* and *long term* improvements.

The role of a *transition roadmap* is to show how the *ATM system* in a particular planning area will be able to migrate in a coherent way from its present state, via a number of feasible intermediate steps (the envisaged situation at the end of the *short* and *medium term*), to a *long term* ‘end state’ in which the *Global ATM Operational Concept* is implemented. The speed of developments (introduction of *operational improvements*) is driven by the expected evolution of performance needs, and constrained by earliest availability of *operational improvements*.

An *implementation plan* is complementary. It has a much shorter time horizon — typically five years — and is usually updated on an annual basis. It is derived from the early (*short-term*) parts of a *transition roadmap*. It lays out a detailed set of *implementation* focused actions — including their timing — for all involved members of the *ATM community*.

Research plans are similar to *implementation plans*, except that they focus on the *research* actions needed today to improve the maturity of *operational improvements* placed in the *medium* and *long term* portions of the *transition roadmap*.

3.2.2 Choosing solutions to mitigate performance gaps

3.2.2.1 Developing a new transition roadmap

11

What selection and sequence of operational improvements addresses current and anticipated performance gaps?

In choosing how to adapt the current *transition roadmap* (or build a new one), the following general guidelines can be used.

The analysis of *performance gaps* (box 8, 2.4 refers) has not only identified (anticipated) *performance gaps* in terms of *performance indicators*, but also provided insight in what caused them. Planners also know where and when the *performance gaps* are expected to occur, and what particular *performance objectives* will not be achieved anymore.

The affected *performance objectives* indicate specific areas that need action to improve performance. This is the point at which the categorization of *operational improvements* according to *performance objectives* is to be used as a tool to develop an appropriate shortlist of candidate solutions. The shortlist is by definition compliant with the *Global ATM Operational Concept*, because it is derived from the full list which was developed with the operational concept in mind (3.1.4 refers).

Solutions (i.e. *operational improvements*) should be selected from the shortlist as follows:

- If (some of) these solutions are already included in the current *transition roadmap*, one should see whether the *performance gaps* cannot be mitigated by accelerating their *deployment* (in time, geographically, in terms of fleet equipage levels, etc.), so as to increase their performance contribution.
- If this is not possible, solutions should be selected which are not yet included in the *transition roadmap*. Consideration should be given to mature *operational improvements* with a proven track record (*deployment* of current best practices).
- Finally, planners can select from *operational improvements* which have not been implemented anywhere yet, but are currently in the process of being researched, developed, and/or validated.

Note that with each planning iteration, the *transition roadmap* will also have to be extended by a number of years corresponding to the *planning cycle* (usually five years), because of the need to maintain a constant time horizon (twenty years).

3.2.2.2 Validating the new transition roadmap

The new *transition roadmap* should be checked as a whole for consistency. Using available *validation* results, (1) a 'shared belief' needs to be developed that the *transition roadmap* has the potential to mitigate the *performance gaps*, and (2) that it is aligned at *global*, *regional* and *local level* (chapter 4 refers). The process of developing a new *transition roadmap* may need to be reiterated until these two criteria are met.

Section 3.1.3 described a set of *validation* perspectives within the context of developing individual *operational improvements* for the generic list of options. The same perspectives should be applied again, but this time for the *transition roadmap* as a whole, and adapted to the specific assumptions and circumstances of the *transition roadmap's* planning area.

Because of the strategic nature of the medium and *long term* portions of *transition roadmaps* (higher uncertainty levels and longer time horizons), it is generally accepted that their *validation* — prior to release during the current *planning cycle* — can be done at a lesser rigour than required for the *validation* of the *short term* portion of the *transition roadmap* (which is to be incorporated in *implementation plans*). However the medium and *long term* portions of the new *transition roadmap* become the basis for focused *validation* activities in the *research plan* which should result in decreased uncertainty by the time the next *planning cycle* is started.

3.2.2.3 Update plans in accordance with the new version of the transition roadmap

12

What are the resulting updates to current roadmaps and plans?

Any change to a *transition roadmap* may require a (partial) rework of existing *implementation plans*.

In particular, what used to be '*medium term*' in the previous (five year old) version of the *transition roadmap*, has now become *short term*, and a corresponding *implementation plan* needs to be developed.

For the same reason, the *research plan* needs to be updated.

3.2.3 Transition roadmap development in practice

The following guidance applies to the development of *transition roadmaps* at *local* (State) and *regional level*.

Develop the proposed *transition roadmap*, in at least three *transition phases*, giving consideration to the:

- existing plans and *transition roadmaps* of the State/*region* (if not already incorporated into the *performance gap* analysis);
- existing *transition roadmaps* and plans of other States/*regions*;
- existing *Global Plan*; and
- existing treaties, agreements and plans with other members of the *ATM community*.

It is acknowledged that States and *regions* may have prior treaties, agreements and plans that need to be addressed.

These *transition roadmaps* should be outlined for the three *transition phases* below, to provide common ground for comparisons (between *local*/State and *regional transition roadmaps*) and to provide relevant information to different groups of *ATM community* members.

- Transition Phase 1 - *short term* (a period typically from now to five years into the future)
- Transition Phase 2 - *medium term* (a period typically from five to ten years into the future)
- Transition Phase 3 - the *longer term* (a period typically from ten to twenty years into the future)

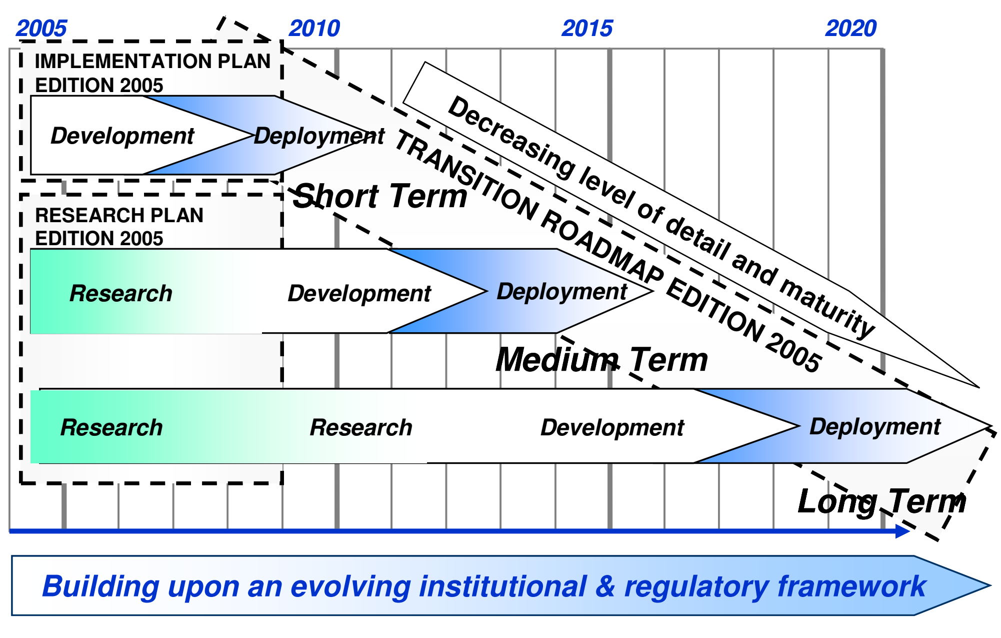

Figure 9 Role of short, medium and long term in a transition roadmap (example)

Transition Phase 1 and to a certain extent Phase 2 are *implementation*-driven (i.e. oriented towards *development* and *deployment*).

Transition Phase 3 is mainly concept-driven because the technical solutions are still in the *research* phase.

However, it is still important to plan for all of these phases:

- to ensure the integrity of the twenty year *transition roadmap* as a whole; and
- to encourage and influence the development of technologies to meet the requirements planned for *transition phases* 2 and 3. This implies that a *research plan* should exist, covering today's (*short term*) *research* activities needed for tomorrow's (*medium* and *long term*) *development* and *deployment*. It is recognized that the commitment of resources towards *research*, *development* and *deployment* is achieved at a *local level*. The *regional transition roadmaps* are intended to reflect the coordinated efforts of the *regional* members.

3.2.3.1 Transition Phase 1

In Transition Phase 1, changes to the *ATM system* infrastructure will be built almost completely on current or already planned or purchased ATM technology (taking into account the long lead times that are common for ATM and avionics systems changes).

Therefore *implementation* issues will probably focus on:

- ATM procedures;
- processes;
- standards; and
- organization.

However, in Phase 1, operational changes will also be deployed, particularly those that:

- are currently in the planning stages (e.g. the *Global Plan*); or
- are about to be implemented as a result of existing *research* and *development* efforts.

The contents of Transition Phase 1 should already be elaborated to the level of (detailed) *implementation plans*.

3.2.3.2 Transition Phase 2

The *deployment* of the *operational improvements* foreseen for Transition Phase 2 is more than five years away, and is typically not yet included in today's *implementation plans* (see Figure 9). While uncertainties are already more reduced in comparison to those in Transition Phase 3, Phase 2 is characterised by the fact that *research* may not yet be completed: more work is needed to validate the *operational improvements* and develop their *performance cases* to the level required for *implementation planning*. It should be noted that the development of *performance cases* occurs in a progressive way: they are refined as the *operational improvements* are taken through their different *life cycle phases*, i.e. from *research* through *development* to *deployment*.

To summarize, the focus of Phase 2 is on:

- building on the foundations laid down in Phase 1; and
- further developing the details of the list of *operational improvements* developed in box 10 of Figure 2.

3.2.3.3 Transition Phase 3

The latter part of Phase 2 and all of Phase 3 are largely conceptual because the technical solutions are yet to be developed.

However, the *transition roadmaps* for these phases will start to influence the development of technology solutions for the *operational improvements* allocated to these Phases. This is one of the real benefits of developing a road map that stretches twenty years into the future.

Planning for Phases 2 and 3 today, allows the *research* and *development plans* and efforts to be focused on providing solutions that achieve:

- the desired performance and
- the expected benefits
- while respecting the long lead times needed for developing the operational concept into implementable *operational improvements*.

4 Ensuring Alignment Throughout the Planning Process

4.1 Planning at global, regional and local level

ATM planning takes place at different levels:

- At ***global level***, through ICAO involvement. At this level, *regional* differences that are obstacles to global interoperability must be resolved.
- At ***regional level***, via Planning and Implementation Regional Groups (PIRGs). At *regional level*, *ATM community* members have agreed to evolve the *ATM system* in accordance with a common *transition plan*. Operating environments and priorities may be different. *Regional performance targets* will be defined. The *regional level* is defined by a division of the world into homogeneous regions with similar characteristics, and a common ATM interest in terms of performance and *transition planning*. The *regional level* is responsible for looking after the network effect of *local* planning activities.
- The ***local level*** corresponds to planning activities of individual members of the *ATM community* (States, air navigation service providers, airspace users, equipment manufacturers, etc.). Subject to *regional* and *local* consultation, *local research* and *implementation plans* should be aligned with their *regional transition plan* such that *regional* performance would improve. *Local performance targets* will be set as a function of *regional performance targets*. *Local performance monitoring* will take place with the aim of aggregating this to *regional performance indicators*.

This approach ensures that planning takes place at the level of its effects — that is, involving all those affected. In this manner, planning takes place at State, interstate, *regional*, interregional and all-regions groups, depending on the extent of its inputs and effects.

The involvement of the different levels in the planning process is illustrated in Figure 10.

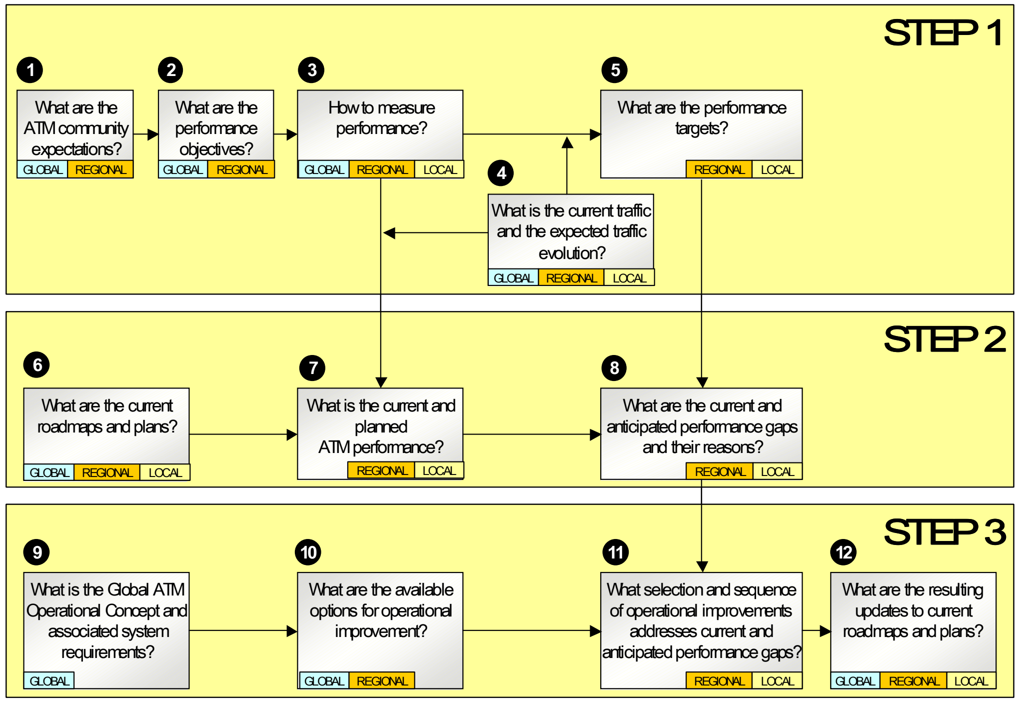

Figure 10 Role of global, regional and local levels

More information on *global*, *regional* and *local* planning can be found in the *Global Air Navigation Plan for CNS/ATM Systems* (Doc 9750).

4.2 Need for negotiated alignment

One of the most critical challenges in transitioning to the *ATM System* envisioned in the *Global ATM Operational Concept* will be the alignment of *global*, *regional* and State/*local* planning and *implementation* activities. It is obvious that there is only one *global* process – but there are at least six *regional* processes (and more if *regional* planning also takes place at the level of homogeneous areas) and 189 State processes (and more if the *implementation planning* is distilled to *local* areas within a State).

Ensuring effective alignment throughout this multi-player and multi-level planning process requires:

- Negotiation between planners on the same *planning level* (for adjacent States and regions) and between levels to produce harmonized, coordinated *transition roadmaps* and plans;
- The common application of common processes – that is, achieving effective standardization of *transition planning* and *implementation* processes in line with the guidance provided in this document;
- The introduction of an improved collaborative planning environment (common information exchange platform), to facilitate the sharing of planning information, to improve the dialogue between planners and to help guide the application of the common process. This subject is addressed in section 4.6.

4.3 Role of guidance material

Harmonization of planning should be ensured right from the beginning, to minimize the need for alignment of incompatible *transition roadmaps* and plans at the end of the process.

This is to be achieved by using *global* guidance material during *regional* planning, and *global/regional* guidance in *local* planning processes.

Such guidance material includes (box numbers refer to Figure 10):

- The *Global ATM Operational Concept* (Doc 9854) and associated system requirements document (box 9), for use at *regional* and *local* planning levels
- The generic (*global*) list of available options for *operational improvement* (box 10), for use at the *regional* planning level
- Region-specific lists of available options for *operational improvement* (box 10), for use at *regional* and *local* planning levels
- The *global* list of *ATM community expectations* (box 1), as specified in Doc 9854 (for use at the *regional* planning level)
- *ATM community expectations* at the *regional level* and their priorities (box 1), for use at *regional* and *local* planning levels
- *Global* and *regional* sets of *performance objectives* (box 2), for use at *regional* and *local* planning levels
- *Global* and *regional* guidance on measuring performance (including common definitions for *performance indicators*) (box 3), for use at *regional* and *local* planning levels
- *Global* and *regional* guidance on developing *long term* traffic forecasts (box 4), for use at *regional* and *local* planning levels

4.4 Aligning performance measurement and assessment

A lack of alignment of performance measurement and assessment between regions and/or States will lead to *transition roadmaps* and plans being based on different assumptions.

Therefore it is important that the data used for the *performance based transition approach* is consistent within and between *regions*. This data includes traffic forecasts, performance measurements and predictions (via *performance indicators*), and *performance targets*.

To achieve consistency of the data, it is imperative that all members of the *ATM community* (in particular *Regions* and States) use a consistent set of assumptions about the future (i.e. compatible forecasting scenarios) and consistent definitions of *performance objectives* and *performance indicators*.

4.5 Aligning the planning processes and their outputs

Performance and *transition planning* will be conducted at *regional* and *local levels*, using a certain *planning cycle*. For an effective coordination at *global level*, a standard cycle should be used with a common period (for example five years), and the cycles of the different *regions* and States should be synchronized. This allows a *global* consolidation to be built into the process at specific checkpoints.

The standard cycle will consider a planning horizon of twenty years. The objective of a *planning cycle* is to adapt the evolution of the *global ATM system* to changes in the following areas:

- After each five year cycle, the progress made in ATM *implementation* and planning should be reviewed, resulting in improved knowledge about *operational improvements* and their (planned) performance for the entire twenty year period (see also Figure 9):
    - The *operational improvements* planned in the old *short term* (five year) plans should now be operational
    - *Research* should have progressed the available knowledge about the *transition roadmap*, so that the *medium term operational improvements* are ready to be transformed into an *implementation plan*, and more and improved understanding is available for the *long term operational improvements*
    - Initial *research* should also have been completed for the first part of the *long term* period, so that more specific *research* can start for these *operational improvements*
- Also, after each five year cycle, the impact of performance-oriented planning parameters should be reviewed:
    - Changing constraints and drivers such as traffic demand growth;
    - Changes to the expectations of society and the *ATM community*;
    - Changing *performance targets*.

The process starts with a **first step**: the development of an updated set of *performance targets* through time. This includes the production of a new *long term* traffic forecast. At this point, a **first global consolidation** takes place to ensure commonality in the underlying forecasting assumptions that are embedded in the socio-political, economic and technical forecasting scenarios. The consolidation also ensures that all regions use the same set of interregional traffic flow forecasts. The result of the first step consists of a consistent *global long term* traffic forecast and agreed *regional performance targets*.

This is followed by a **second step**: *performance assessment* and identification of current and anticipated *performance gaps*.

Based on this information, each region reviews its list of candidate *operational improvements* and updates its *transition roadmaps*, *research plans* and *implementation plans* (**third step**). After this exercise, a **second global consolidation** activity will take place, which will result in the updated set of *regional transition roadmaps*, which together make up the *global transition plan*.

A **fourth step** in the process generates lessons learned (at *global level*), which become an input to the **fifth and last step**: maintaining the guidance material and the overall planning process itself.

In case of timing constraints, the fourth and fifth steps could possibly overlap with the first step of the next *planning cycle*. All in all, the process could take up to seven years, while still maintaining a schedule in which a new cycle starts every five years.

4.6 Improving the planning environment

This collaborative planning process will be aided substantially by development of a virtual (rather than the current paper-based) planning environment, with the transfer of information conducted in real time within a distributed information network (e.g. via the Internet). This will enable – in fact oblige – compliance with more rigid decision-making processes that require consideration of the concept of global harmonization – and a "systems approach" to planning.

It will also place all of the material required for informed decision-making at easy access – including the processes used by other States and regions, the information which those States and regions used to make their decisions, and importantly, lessons learned. This will reduce the risk that States and regions "re-invent the wheel", and will allow the costs of the improved aircraft and other infrastructure capabilities to be spread over a much larger group of *ATM community* members.

By its very nature, such a virtual planning environment should be *global* in nature. It is expected that ICAO would develop, operate and maintain this planning environment within the context of global ATM planning support.

Appendix A
Illustrations of Operational Improvements

Operational improvements (OIs) are changes to the *ATM system* that are on the transition path towards the *Global ATM Operational Concept* and result in a direct *performance* enhancement. An *operational improvement* is a set of elementary changes that are intended to be implemented together to deliver performance. An *operational improvement* is a transition step in a *transition roadmap* (1.5.10 refers).

To illustrate the above definition, this appendix contains a list of example *operational improvements*:

A.1 **Airborne Spacing**
A.2 **Airport and Flight Information Sharing**
A.3 **Decision Support for Sector Operations**
A.4 **Situational Awareness for Aerodrome Ground Operations**
A.5 **Flexible Airspace Structures**
A.6 **Data Link Services**

Each *operational improvement* is described as follows:

1. Reference ATM system (Starting point)

The reference *ATM system* is the baseline situation that will be improved by the *operational improvement*.

2. OI description

In this field the OI is described briefly and the description is focused on the essential changes.

3. Primary Performance Purpose

This field lists the *Key Performance Areas* that are most affected by the OI and describes its effect for each area.

4. Links to the operational concept components of the Global ATM Operational Concept

As reference links are made to the operational concept components of the *Global ATM Operational Concept*. The links could be used to look up information about the conceptual background.

5. Links to ATM system requirements

As reference links are made to the ATM system requirements (requirement reference numbers as specified in the *ATM System Requirements Supporting the Global Air Traffic Management Concept* document). This gives an overview of the ATM system requirements that need to be taken into account when implementing this *operational improvement*. The links to the ATM system requirements form an illustrative list.

A.1 Airborne Spacing

Reference ATM system (Starting point)	In this state, air traffic situational awareness information is provided on the surrounding traffic to the airspace users without change of the roles and responsibilities between pilots and controllers.
OI Description	Controllers will be able, under defined conditions, to delegate the spacing tasks to the flight crew of suitably equipped aircraft. The flight crews will perform these new tasks using new aircraft capabilities. The core roles of controllers and flight crews remain unchanged. The flight deck is responsible for spacing according to ground instructions and responsibility for separation remains with the ground. Agreement between the controller and the pilot is a prerequisite. Instructions are limited in time or distance. This requires that a sufficient number of aircraft are equipped to achieve benefits. Three examples of ATM operations are considered: **Sequencing and merging operations** The controllers will be provided with a new set of instructions directing, for example, the flight crews to establish and to maintain a given time or distance from a designated aircraft. This application could be used to facilitate traffic synchronization to the runways. **In-trail procedure in oceanic airspace** Under the appropriate circumstances, the controller will clear the flight crew to climb or descend to a given flight level. It will allow aircraft to fly at more optimum level. **Enhanced crossing and passing operations** To solve conflicts between two aircraft (or allow aircraft to avoid hazards) the controller will use new ATC instructions and procedures that will use new capabilities of aircraft to fly relatively to one another or avoid the hazard.
Primary Performance Purpose	• **Capacity**: The delegation of tasks to the pilots is expected to allow the handling of more flights per airspace volume per time period. • **Efficiency**: There are fuel benefits from allowing aircraft to climb whilst in oceanic airspace (e.g. in-trail climb procedures). • **Environment**: Reduction of fuel consumption will reduce gaseous emissions and less dense traffic in the vicinity of airports could reduce noise impact. • **Safety**: The involvement of more actors in the separation provision is expected to have a positive effect on safety, e.g. through additional redundancy in conflict detection and resolution.

Links to Operational Concept Components	• Conflict management (CM) • Traffic Synchronization (TS) • Airspace User Operations (AUO)
Links to ATM System Requirements	R48, R53, R61, R66, R85, R115, R211, R213

A.2 Airport and Flight Information Sharing

Reference ATM system (Starting point)	Collaborative decision-making (CDM) process between the service provider and the major airport users with **limited real-time access** to **status information and operations factors**. Current collaborative decision-making process is locally adapted and may not be globally interoperable.
OI Description	Airport operators will participate in airport information sharing and improve the planning of their resources by using real time flight information accessible via CDM. Aircraft operators participate in sharing of relevant real time flight plan information via CDM and improve their planning of schedules by using the shared information from other stakeholders. Where feasible they can indicate their priorities in managing their own flights within the arrival schedules. Service providers will be aware of the requirements of other users and service providers and the agreed collaborative rules to resolve competing requests for ATM resources. Local CDM processes at aerodromes will build on sharing of key flight scheduling related data that will enable all players to improve their awareness of the aircraft status.
Primary Performance Purpose	• **Cost Effectiveness**: CDM allows the trade-off be made across the ATM community. • **Efficiency**: Collaboration allows ATM system users to operate in a manner that is consistent with their individualized business cases that may not be known to other ATM system participants. • **Environment**: Gains in efficiency often result in decreased fuel consumption that can lead to performance gains in the environment KPA. • **Participation by the ATM community**: Increased participation by the airspace user and better information sharing.
Links to Operational Concept Components	• Traffic Synchronization (TS) • Demand and Capacity Balancing (DCB) • Aerodrome Operations (AO) • Airspace User Operations (AUO) • ATM Service Delivery Management (ATM SDM) • [Information Management, Collaborative Decision-making]
Links to ATM System Requirements	R21, R23, R24, R25, R26, R27, R29, R30, R32, R33, R34, R35, R36, R53, R55, R56, R67, R71, R80, R83, R84, R92, R98, R100, R112, R113, R114, R115, R125, R143, R145, R146, R153, R154, R155, R159, R160, R161, R169, R178, R179, R211

A.3 Decision Support for Sector Operations

Reference ATM system (Starting point)	Control of en-route and TMA sectors is supported by safety nets. The early detection of potential conflicts is limited and not very accurate. There is a lack of decision support.
OI Description	The tasks of controllers will become supported by more automation. The detection up to approximately 20-30 minutes before the event of potential conflicts between flights, between flights and hazards or between flights and restricted airspace will be supported by capabilities, which will facilitate earlier handling of such events. The monitoring for conformity of the traffic situation to planning and ATC clearances will be supported by flight path monitoring capabilities. Improvements will be made to safety nets. For early resolution of planning conflicts basic levels of 'what-if' probing functionality will become available. These changes will have an impact on the roles and tasks of both the executive and planning controller. All these changes should be part of an integrated update of the controller working position and of operational procedures.
Primary Performance Purpose	• **Capacity**: The reduction of tactical action allows managing more traffic within the same acceptable workload limits. The workload will be better distributed over the team. • **Cost effectiveness**: The reduction of workload allows managing the same volume of traffic with fewer resources. • **Efficiency**: Early resolution of potential problems will generally lead to a lower number of flight path modifications while reducing excess route lengths and avoiding unnecessary speed control. • **Safety**: Decision support systems allow better anticipation of potential conflicts. Conflict resolution strategy will be optimized and the need for tactical action will be reduced, thereby reducing risk.
Links to Operational Concept Components	• Airspace User Operations (AUO) • Traffic Synchronization (TS) • Conflict Management (CM) • ATM Service Delivery Management (ATM SDM) *Note: There is a need for effective Information Management.*
Links to ATM System Requirements	R06, R11, R27, R31, R53, R61, R65, R66, R73, R83, R117, R183

A.4 Situational Awareness for Aerodrome Ground Operations

Reference ATM system (Starting point)	Weather can severely impede aerodrome ground operations. Decreased situational awareness — particularly in bad weather — significantly reduces airport capacity in order not to jeopardize safety.
OI Description	Capabilities for detecting the position and movements of all vehicles and aircraft on the manoeuvring area and of all aircraft on aprons will be introduced, allowing for better situational awareness both in the air and on the ground. Conflict detection and resolution will be provided on all aerodrome movement areas, including runways (e. g. to prevent runway incursions), taxiways and aprons. This will contribute to better control of ground movements, under low visibility conditions.
Primary Performance Purpose	• **Access and Equity**: Through increased capacity and more efficient low visibility operations. • **Capacity, Efficiency and Environment**: Through optimized aircraft taxi and handling. • **Flexibility**: Through better use of existing ground resources (runways, taxiways, gates, etc.) • **Safety**: Through better situational awareness and conflict detection tools.
Links to Operational Concept Components	• ATM Service Delivery Management (ATM SDM) • Demand & Capacity Balancing (DCB) • Airspace User Operations (AUO) • Conflict Management (CM)
Links to ATM System Requirements	R11, R23, R24, R25, R26, R29, R30, R32, R33, R35, R61, R73, R77, R80, R84, R92, R100, R101, R117, R127, R128, R143, R154, R167, R168, R177, R178, R197, R199, R202, R211, R213, R214, R215, R216

A.5 Flexible Airspace Structures

Reference ATM system (Starting point)	Airspace structures are static and are generally constrained by national or facility boundaries. The airspace management is not very flexible and is based on pre-planned scenarios.
OI Description	Flexible airspace structures will support flights to be operated principally on airspace user preferred routes. Airspace management will have evolved to a very dynamic system. The focus is to ensure that resources are available where and when necessary. There will be a highly dynamic use of sectorization scenarios. All airspace will be the concern of ATM and will be a useable resource; airspace management will be dynamic and flexible. Any restriction on the use of any particular volume of airspace will be considered transitory and all airspace will be managed flexibly. Airspace boundaries will be adjusted to particular traffic flows and should not be constrained by national or facility boundaries.
Primary Performance Purpose	• **Capacity**: Airspace capacity will be better utilized and capacity will be increased by a sector design adjusted to the traffic flows. • **Cost Effectiveness**: This OI will provide an increase in annual network productivity through dynamic allocation of resources. • **Efficiency**: Higher flight efficiency due to maximized capability for enabling user preferred routing.
Links to Operational Concept Components	• Airspace Organization and Management (AOM) • ATM Service Delivery Management (ATM SDM) • Demand & Capacity Balancing (DCB)
Links to ATM System Requirements	R01-05, R6, R15-20, R32, R34-36g, R67-68, R71-73, R99, R105-109, R112-114, R121-125, R148-152, R159-161

A.6 Data Link Services

Reference ATM system (Starting point)	An ATM environment which uses voice communication as the primary means of communication between ground and aircraft.
OI Description	Data link capabilities will become available to replace some radiotelephony (R/T) exchanges. The system automation and controllers will also be able to make use of some aircraft derived data (ADD), giving a more accurate view of the situation. Aircraft will have to provide ADD to the Air Traffic Services. Also data link capabilities will need to be available onboard the aircraft. From the pilot's perspective the change is mostly related to the introduction of data link capabilities to replace some R/T messages.
Primary Performance Purpose	• **Capacity**: The reduced R/T load per movement allows the safe handling of more traffic per unit of time within acceptable workload levels. Availability of ADD will improve the quality of the support provided by automation • **Cost Effectiveness**: The reduction of workload allows managing the same volume of traffic with fewer resources. • **Safety**: Transition to the use of data link communications reduces the probability of misunderstandings and provides a back-up for voice communication.
Links to Operational Concept Components	• Airspace User Operations (AUO) • Traffic Synchronization (TS) • Conflict Management (CM) • ATM Service Delivery Management (ATM SDM)
Links to ATM System Requirements	R07, R27, R31, R98, R148

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