RWANDA

CIVIL AVIATION AUTHORITY

ADVISORY CIRCULAR
RCAA-AC-PANSOPS003

GUIDANCE ON IMPLEMENTATION OF PERFORMANCE BASED NAVIGATION (PBN) IN RWANDA

1.0 PURPOSE

This Advisory Circular provides guidance on the procedures and steps to be followed by Air Navigation Service Providers in the implementation of Performance Based Navigation (PBN) in the Rwandan airspace.

2.0 INTRODUCTION

The PBN concept specifies that aircraft RNAV and RNP system performance requirements be defined in terms of the accuracy, integrity, continuity and functionality, which are needed for the proposed operations in the context of a particular airspace concept. The PBN concept represents a shift from sensor-based to PBN. Performance requirements are identified in navigation specifications, which also identify the choice of navigation sensors and equipment that may

be used to meet the performance requirements. These navigation specifications are defined at a sufficient level of detail to facilitate global harmonization by providing specific implementation guidance for States and operators.

A navigation specification is a set of aircraft and aircrew requirements needed to support a navigation application within a defined airspace concept. The navigation specification defines the performance required by the RNAV or RNP system as well as any functional requirements such as the ability to conduct curved path procedures or to fly parallel offset routes

RNAV and RNP systems are fundamentally similar. The key difference between them is the requirement for on-board performance monitoring and alerting. A navigation specification that includes a requirement for on-board navigation performance monitoring and alerting is referred to as an RNP specification. One not having such requirements is referred to as an RNAV specification. An area navigation system capable of achieving the performance requirement of an RNP specification is referred to as an RNP system.

PBN offers a number of advantages over the sensor-specific method of developing airspace and obstacle clearance criteria, i.e.:

a) reduces the need to maintain sensor-specific routes and procedures, and their associated costs;

b) avoids the need for developing sensor-specific operations with each new evolution of navigation systems, which would be cost-prohibitive;

c) allows for more efficient use of airspace (route placement, fuel efficiency and noise abatement);

d) clarifies how RNAV and RNP systems are used; and

e) facilitates the operational approval process for operators by providing a limited set of navigation specifications intended for global use.

3.0 REFERENCES

2.1 Part 22 of Civil Aviation Regulations

2.2 Part 6 of Civil Aviation regulations

2.3 Part 10 of civil Aviation regulations

2.4 ICAO ICAO PANS Doc 8168 Part II - Aircraft operations - Construction of Visual & instrument flight procedures

2.5 ICAO Doc 9613 - Performance Based Navigation Manual

2.6 Rwanda Civil Aviation Technical Standards (RCATS)

4.0 IMPLEMENTATION PROCESSES

Implementing RNAV or RNP applications in the Rwandan airspace should be in accordance with the following three processes:

- Process 1- Formulate an airspace concept
- Process 2- Identify ICAO navigation specification for implementation
- Process 3- Plan and implement.

4.1 PROCESS 1-FORMULATE AN AIRSPACE CONCEPT

An airspace concept is a general vision or master plan for a particular airspace. It is driven by specific strategic objectives such as **safety, capacity, efficiency, access and environment** as identified by airspace users, air traffic management(ATM), airports as well as environmental and government policy.

Besides strategic objectives, airspace users (military/civil, air carriers, business/general aviation) and ATM shall consider operational requirements as well. In addition, policy directives concerning environmental mitigations, domestic and international user requirements as well as airworthiness and operational approvals for operators shall be considered.

An analysis should be carried out for all requirements (safety, efficiency, capacity) so as to identify trade-offs necessary to strike a balance between competing requirements. Consideration should be given to the primary and alternate means of meeting the requirement, methods for communicating to airspace users the requirements and availability(and outage) of services. A detailed plan for transition to the new airspace concept needs to be developed.

4.1.1. Step 1- Formulate Airspace Concept

Airspace concept should be defined in sufficient detail so that supporting navigation functions can be identified.

A team made up of air traffic controllers, airspace planners (from ANSP), pilots, procedure design specialists, avionics specialists, flight standards and airworthiness regulators and airspace users should carry out elaboration of the airspace concept.

Details on the following factors should be given:

- Airspace organization and management (i.e, ATS route placement, IDs/STARs, ATC sectorization)
- Separation minima and route spacing;

- Instrument approach procedure options;
- How ATC is to operate the airspace
- Expected operations by flight crew and
- Airworthiness and operational approval.

4.1.1.1. Insets 1 to 4 below provide expanded information for the teams' consideration:

Inset 1 — Airspace user requirements

Airspace concept developers should consider the needs of the airspace user community in a broad context, i.e. IFR, VFR, military and civil aviation (e.g. air carrier, business and general aviation). Consideration should also be given to both domestic and international user requirements.

The overall safety, capacity and efficiency requirements of implementation should be balanced; an analysis of all requirements, and trade-offs among competing requirements, will need to be completed; primary and alternate means of meeting requirements should be considered; methods for communicating to airspace users the requirements and availability (and outages) of services need to be identified; and detailed planning needs to be undertaken for the transition to the new airspace concept.

Inset 2 — Airspace requirements

In order to identify the airspace requirements, it is necessary to:

a) gather and analyze data on current and expected traffic growth within and surrounding the specific airspace.

b) understand the traffic flows, volume of traffic, and the composition of air traffic both in the airspace under consideration and adjoining airspace. It is important to consider transition airspace and procedures for integrating operations across airspace boundaries and national borders.

c) Assess the surveillance, communications and navigation infrastructure available in the airspace.

d) ATS route and other procedure design criteria should be adopted from existing ICAO material to the maximum extent possible.

e) Identify the minimum navigation functions needed to support the operational requirement and compare these with the equipage of the aircraft fleets operating in the subject airspace.

f) define the required ATS route spacing prior to design of the airspace, route or procedure. ATS route spacing must be based on the overall safety, capacity and efficiency requirements of the airspace concept.

Airspace requirements may identify a need for on-board performance monitoring and alerting by, for example, specifying a need for closely spaced parallel routes (i.e. routes with consistent route spacing on both straight and turning segments). These types of requirements need to be carefully noted as they directly determine the required navigation functions discussed in 2.3.4.

Inset 3 — Approach requirements

As a general principle, approach requirements should take advantage of existing aircraft capabilities as much as possible. In addition, designers should use existing procedure design criteria to minimize the cost of operator approval and harmonize implementation across national boundaries.

In addition to the above considerations, the designer will need to determine which type(s) of approaches are required in order to meet the needs of the airspace. Considerations include:

a) straight-in or curved approach;

b) straight or curved missed approach;

c) single or multiple runways, such as:

   i) parallel or converging multiple runways;

   ii) independent or dependent runway approaches;

d) need for back-up approach procedures (e.g. if a local GPS outage occurs, what is available for approach guidance?).

Inset 4 — Other requirements

In designing the airspace concept (route or procedure), the designers should identify:

— environmental factors requiring consideration and accommodation; and
— any expected impacts to flight plan submission or processing.

4.1.2 Step 2: Assessment of Existing Fleet Capability and Available Navaid Infrastructure.

Understanding the capabilities of aircraft that will be using the airspace is essential in determining the type of implementation that is feasible to the users. Additionally, understanding what is available in terms of navaids infrastructure is essential in determining how and if a navigation, specification can be supported.

The following should be considered:

4.1.2.1 Assessing Aircraft Fleet

Aircraft fleets are not homogeneous in terms of RNAV system capability. Different generations of aircraft may be active in airspace. Therefore, the airspace has to accommodate all aircraft operating both on old and new technology.

This mixed- equipage traffic environment will be inevitable during the transition period. It is therefore necessary to know the characteristics and level of equipage of the fleet operating in the airspace. Questions that may be considered include:

- Are sufficient aircraft equipped with GNSS capability?
- Can failures of GNSS be mitigated by other means of navigation (e.g. DME- based RNAV, conventional navigation or ATS surveillance system)?
- Do all IFR approved aircraft carry VOR and DME equipment and is that equipment integrated into an RNAV system?
- When there are, insufficient navaids to provide adequate signal coverage, can the gaps in coverage be accommodated by reliance on aircraft inertial systems?

If a mixed RNAV performance environment (or a mixed RNAV and conventional environment) has been decided upon, ATC requirements must also be addressed for those operations. Handling traffic of mixed navigation equipage can, depending on the level of mixed equipment and operations, adversely affect capacity in the airspace and place an unsuitable workload on controllers.

4.1.2.2. Assessing Navaid Infrastructure

4.1.2.2.1 Satellite navigation based on Global Navigation Satellite Systems (GNSS) has made RNAV a reality for many operators. It has also made it possible for ANSPs to consider a full transition to RNAV-based en route and terminal operations. However, since such a transition may take a number of years, ANSP should identify a need to maintain some ground-based navaids, either to provide alternate input to RNAV systems, to support a reversionary conventional navigation environment or to provide conventional navigation environment for non- RNAV equipped users.

4.1.2.2.2 Factors determining the scope of a ground navaids replacement programme include:

i. The rate at which aircraft operators equip their fleets with GNSS capable avionics.
ii. The extent of the requirement to retain some ground navaids for users not equipped with GNSS, or as back-up to GNSS (e.g. partial mitigation to the potential hazard posed by interference with GNSS signals)
iii. The existence and age of existing navaid infrastructure.

4.1.2.2.3 Implementing an RNAV application should not in itself become the cause for installing new navaid infrastructure. However, the introduction of RNAV application could result in some existing navaids being moved (e.g. DMEs relocated when they no longer have to be co-located with VOR).

4.1.3 Step 3-Assessment of the Existing ATS Surveillance System and Communication Infrastructure and the ATM system.

PBN is only the navigation component of CNS/ATM. It cannot be safely and successfully implemented without due consideration of the communication and ATS surveillance infrastructure available to support the operation. e.g., an RNAV 1 route will require different ATS route spacing in a radar or non-radar environment. Similarly, availability of communication between aircraft and air traffic services may influence the level of air traffic intervention capability needed for safe operations.

4.1.3.1. ATS Surveillance Infrastructure

Current ATS surveillance infrastructure is composed of primary and/or secondary surveillance radar to support en route, terminal and approach operations. Newer systems such as ADS-B can be expected to play an increasing role, particularly in procedurally controlled environments. However, the dependence of ADS on the navigation solution has to be considered when undertaking the overall evaluation of the operation (See assessment of ADSP to Support Air Traffic Services and Guidelines for implementation (ICAO circular 311)

4.1.3.1.1 Without robust ATS surveillance systems, RNAV route spacing is large. Implementation of RNP in such an environment can compensate to some extent for the lack of ATS surveillance coverage.

4.1.3.2 Communication Infrastructure

3.1.3.2.1 Currently, voice communication service is provided through VHF and HF radio. VHF service is particularly widely available and is expected to be maintained (with or without augmentation by data link communications).

4.1.3.3 ATM Systems

3.1.3.3.1 The evolution of the ATM system to meet the needs of PBN implementation should be considered. Reduction of separation minima affects the alert limits of conflict detection tools, or if different separation minima are used for different route types or aircraft capabilities, this should be considered in the ATM system evolution.

If required time of arrival is included in an airspace concept, the automation system would need to be designed accordingly. This same consideration applies with use of equipment classifications (e.g., flight plan suffixes); controller merging and spacing tools and any other air traffic control automation features that enable the of maximization the benefits of RNAV and RNP.

4.1.4 Step 4-Identify Necessary Navigation Performance and Functional Requirements.

4.1.4.1 The decision on the choice of an ICAO RNAV or RNP navigation specification is not only determined by aircraft performance requirements (e.g. accuracy, integrity, continuity, availability), but may also be determined by the need for specific functional requirements (e.g., leg transitions/path terminators, parallel offset capabilities, holding pattern, navigation data bases)

4.1.4.2 The proposed navigation functional requirements also need to consider:

a) The complexity of the RNAV procedures envisaged; the number of way points needed to define the procedure; the spacing between waypoints and the need to define how a turn is executed; and

b) Whether the procedures envisaged aim simply to connect with enroute operations and can be restricted to operations above minimum vectoring altitude/ minimum sector altitude, or are the procedures expected to provide approach guidance.

4.1.5 –Step 5 Go to Process 2

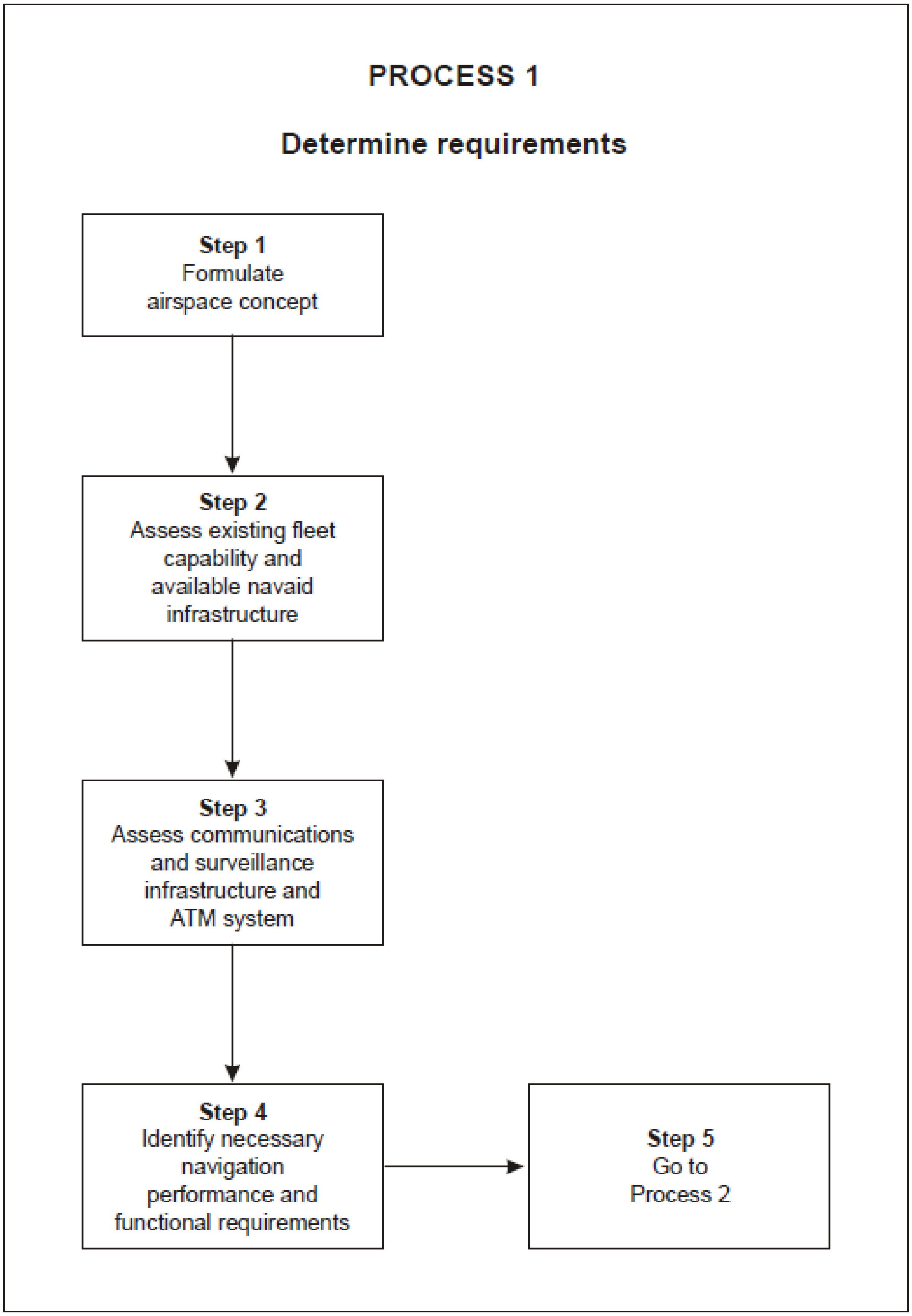

Figure 1-B-2-1 Summary of Process 1

4.2 PROCESS 2- IDENTIFY ICAO NAVIGATION SPECIFICATION FOR IMPLEMENTATION

The goal of process 2 is to identify ICAO navigation specification(s) that will support the airspace concept and navigation functional requirements as defined in process 1. The navigation functional requirements, fleet capability and CNS/ATM capabilities already identified in process 1 will provide the specific context against which ability to meet the requirement of a particular ICAO navigation specification can be evaluated.

4.2.1 Step 1-Review ICAO Navigation specification in Volume 2 of PBN Manual (doc 9613)

a) Step 1 is aimed at finding a potential match between the requirements identified in process 1 and those contained in one or more of the ICAO navigation specifications in volume II.

b) In reviewing one or more possible ICAO navigation specifications, there will be a need to consider the output of process 1 with respect to:

i) the ability of the existing aircraft fleet and available navaid infrastructure to meet the requirements of a particular ICAO specification (step 1A in figure 1-B-3-1) and

ii) the capabilities of the communication and ATS surveillance infrastructure, and ATM system to support implementation of this particular ICAO navigation specification (step 1B in figure 1-B-3-1)

4.2.1.1 Examples of some questions to be considered when comparing the output from process 1 with the ICAO navigation specifications are shown in inset 5.

Inset 5 — Examples of questions to be considered when comparing the output from Process 1 with the ICAO navigation specifications

Is the anticipated route structure (from the airspace concept) compatible? Consider the spacing between individual routes and the existence of multiple routes.

Are the RNAV systems designed to operate with the same navaid infrastructure?
Is the available navaid infrastructure (assessed in Process 1) the same as the navaid infrastructure associated with the ICAO navigation specification?

4.2.2 Step 2-Identify appropriate ICAO Navigation Specification to apply in the specific CNS/ATM environment.

4.2.2.1 If it is determined that a particular ICAO navigation specification in Vol. II can be supported by the fleet equipage,navaid infrastructure, communication and ATS surveillance and ATM capabilities available, proceed to process 3-planning and Development.

4.2.2.2 If an ICAO navigation specification cannot be supported, continue with process 2, step 3.

4.2.3. Step 3-Identify trade-offs with airspace concept and functional requirements (if necessary).

4.2.3.1. This step is followed when an exact match between a particular ICAO navigation specification and the fleet equipage, navaid infrastructure, communications and ATS surveillance and ATM capabilities available cannot be made.

4.2.3.2 The aim is to change either the airspace concept or navigation function requirements, in order to select an ICAO navigation specification. e.g., operational requirements reflected in the airspace concept could be reduced, or alternative means identified to achieve a similar (if not identical) operational result.

Note: Safety can be improved by establishing uniform aircraft and navigation requirements across varying regions. Navigation specifications are also significant sources of cost control to operators.

Navigation specifications have associated aircraft requirements, navaid infrastructure expectations and route spacing requirements.

4.2.3.3 Airspace concept and required navigation functions identified in process 1, should be revisited to determine what trade-offs can be made so as to implement a particular existing ICAO navigation specification.

The following are the reasons which could explain the lack of match:

a) The original analysis of the navigation functional requirements (from process 1) did not correctly identify all functions required for the airspace concept. Perhaps a functional capability was omitted or because it was unnecessarily identified. Initial analysis could have omitted some or all the leg types required for RNAV in terminal airspace, or failed to require fixed-radius transitions where closely spaced parallel tracks are to be implemented in enroute applications.

b) The navigation function requirements identified in process 1 were defined around existing fleet capability operating in the airspace, with the expectation that this capacity would be appropriate for the airspace concept. If use of this fleet capability remains the target, then it would be necessary to change the airspace concept.

Example

Trade-off of a navigation functional requirement

If the only difference between the ICAO navigation specification and the navigation functional requirements identified in Process 1 is a requirement for parallel offset capability, it might be possible to adjust the functional requirement. An alternative to parallel offset capability in a continental airspace could be the creation of radar vectoring areas in which aircraft could be vectored off track to facilitate climb and descent of overtaking traffic.

4.2.3.4 In most instances, it will be possible to make sufficient trade-offs in the original airspace concept or required navigation functions from process 1, such that an existing ICAO navigation specification can be selected. Once trade-offs have been made that will allow selection of an ICAO navigation specification, proceed to process 3: Planning and Implementation.

4.2.3.5 If in the rare case that it is determined that it is impossible to make trade-offs in airspace concept and/or navigation function requirements, a new navigation specification would have to be developed. (Chapter 5)

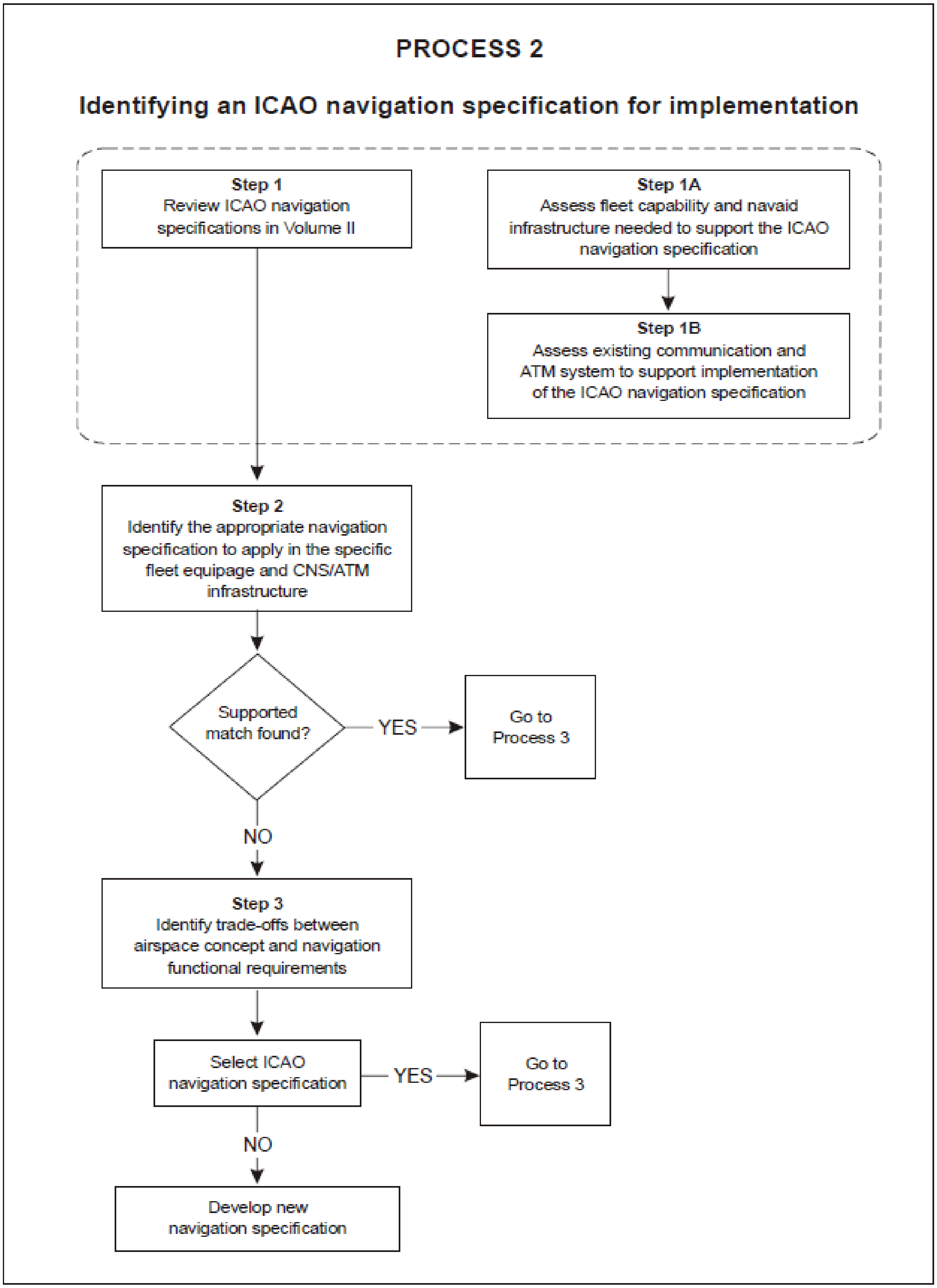

Figure I-B-3-1. Summary of Process 2

4.3 PROCESS 3: PLANNING AND IMPLEMENTATION

Process 3 is concerned with planning and implementation of PBN. It follows upon completion of processes 1 and 2. Detailed discussion of some important considerations that should be kept in mind when framing the implementation plan are given in inset 6 below.

Inset 6 — Implementation considerations

In applying one of the ICAO navigation specifications for oceanic, remote continental and continental en-route operations as described in Volume II, consideration should be given to the need for regional or multi-regional agreement. This is because connectivity and continuity with operations in adjoining airspace need to be considered to maximize benefits. For terminal and approach operations, the implementation of an ICAO navigation specification in Volume II is more likely to occur on a single-State basis. Some TMAs are adjacent to national borders for which multinational coordination would likely be required.

Where compliance with an ICAO navigation specification is prescribed for operation in an airspace or ATS routes, these requirements are to be indicated in the State's aeronautical information publication.

The decision to mandate a requirement for one or more ICAO RNAV or RNP specifications should only be considered after several factors have been taken into account. These include, but are not limited to:

a) the operational requirements of the airspace users (civil/military, IFR operations), as well as those of ANSPs;

b) regulatory requirements at both international and national levels;

c) the proportion of the aircraft population currently capable of meeting the specified requirements, and the cost to be incurred by operators that need to equip aircraft to meet the requirements of the navigation specification;

d) the benefits in terms of safety, capacity, improved access to airspace/airports or environment to be derived from implementing the airspace concept;

e) the impact on operators in terms of additional flight crew training;

f) the impact on flight crew in terms of workload; and

g) the impact on air traffic services in terms of controller workload and required facilities, (including automation and flight plan processing changes). Particular attention must be given to possible workload and efficiency impacts of operating mixed navigation environments. (See Inset 7 following Step 7 for further discussion of mixed equipage.)

Navigation functional requirements, fleet capability and CNS/ATM capabilities will have been identified in process 1. The ICAO navigation specification(s) will have been selected in process 2. Possible additional national or regional requirements for implementation should be identified and incorporated.

STEPS IN PROCESS 3

4.3.1 Step 1-Formulate Safety Plan

4.3.1.1The first step in process 3 is to formulate a safety plan for PBN implementation (See guidance, SMM manual)

4.3.1.2 Depending on the nature of implementation, this could be a national or regional plan. Normally, the ANSP safety team, to the satisfaction of the regulatory authority, would develop such a plan. The safety plan details how the safety assessment is to be accomplished for the proposed RNAV or RNP implementation.

4.3.2-Step 2-Validate Airspace Concept for Safety

4.3.2.1 This step involves completing a safety assessment. From the assessment, additional safety requirements may be identified which need to be incorporated into the airspace concept prior to implementation.

4.3.2.2 Four validation means are traditionally used to validate airspace concept:

a) airspace modeling

b) fast-time simulation (FTS)

c) real-time simulation (RTS)

d) live ATC trials.

4.3.2.3 For simple airspace changes, it may be necessary to use all of the above validation means for any one implementation. For complex airspace changes, FTS and RTS can provide essential feedback on safety (and efficiency) issues and their use is encouraged. Application of new navigation specifications can range from simple through major changes to the airspace concept.

The four types are discussed below:

4.3.2.4 Airspace Modelling.

Airspace modeling is beneficial because it provides some understanding of how the proposed implementation will work, yet it does not require the participation of controllers or pilots. Airspace models are computer-based, so it is possible to make changes quickly and effectively to ATS routes, holding patterns, airspace structures or sectorization to identify the most beneficial scenarios (i.e. those that are worth carrying forward to more sophisticated validations).

Using computer-based airspace model can make it easier to identify non-viable operating scenarios so that unnecessary expense and effort is not wasted on more advanced validation phases.

The main role of an airspace model is to eliminate non-viable airspace scenarios and to support the qualitative assessment of further concept development.

4.3.2.5 Fast-Time Simulation (FTS)

Following the computer- based airspace modeling phase,it can be useful to run a fast time simulation. A more sophisticated assessment that airspace modeling, an FTS returns more precise and realistic results while still not requiring the active participation of controllers or pilots; however, in terms of data collection and input, preparation can be demanding and time consuming.

4.3.2.6 Real-Time Simulation (RTS)

The most realistic way to validate an airspace concept is to subject the viable scenarios to real-time simulation (RTS). These simulators realistically replicate ATM operations and require the active participation of proficient controllers and simulated ‘pseudo’ pilots. In some cases, sophisticated RTS can be linked to multiple-cockpit simulators so that realistic flight performance is used during simulation. One of the difficulties that can be encountered with real time simulation is that the navigation performance of the aircraft is too perfect. Aircraft in RTS may operate with a navigation precision that is unrealistic, given weather realities, individual aircraft performance etc. In such cases, error rates from live operations are analyzed and can be scripted into RTS.

4.3.2.7 Live ATC Trials

Live ATC trials are generally used to verify operating practices or procedures when subtleties of the operations are such that FTS and RTS do not satisfy the validation requirements.

It should be noted that step 3-Procedure Design must be completed before live ATC trials can be conducted.

4.3.3 Step 3-Procedure Design

4.3.3.1 A total system approach to implementation of the airspace concept means that the procedure design process is an integral element. Therefore, the procedure designer is a key member of the airspace concept development team.

4.3.3.2 Procedure designers need to ensure that the procedures can be coded in ARINC 424 format. Currently this is one of the major challenges facing procedure designers. Many are not familiar with either the path and terminators used to code RNAV systems or the functional capabilities of different RNAV systems (See attachment A of volume 2 of the PBN Manual, ICAO Doc). Many of the difficulties can be overcome however, if close cooperation exists between procedure designers and the data houses that provide coded data to navigation data base providers.

4.3.3.3 Once these procedures have been validated and flights inspected (see step 4 and 6), they are published in the AIP along with any changes to routes, holding areas or airspace structures.

4.3.3.4 The complexity involved in data processing of RNAV system database means that in most instances, a lead period of two AIRAC cycles is required (see volume 1, attachment B, section 3 for more details).

4.3.4 Step 4- Procedure Ground Validation

4.3.4.1 The development of an RNAV or RNP instrument flight procedure or ATS route follows a series of steps from the origination of data through survey to the final publication of the procedure and subsequent coding of it for use in an airborne navigation database (see Attachment B of volume 2 of PBN Manual). At each step of the procedure design process, there should be quality control procedures in place to ensure that the necessary levels of accuracy and integrity are achieved and maintained. These quality control procedures are detailed in PANS-OPS (Doc 8168), Volume II.

4.3.4.2 After designing the procedure, and before an RNAV or RNP route or procedure is published, PANS-OPS (Doc 8168) require that each procedure undergo a validation process. The objective of validation is to:

a) provide assurance that adequate obstacle clearance has been provided;

b) verify that the navigation data to be published, as well as that used in the design of the procedure, are correct;

c) verify that all required infrastructure, such as runway markings, lighting, and communications and navigation sources, are in place and operative;

d) conduct an assessment of flyability to determine that the procedure can be safely flown; and

e) evaluate the charting, required infrastructure, visibility and other operational factors.

4.3.4.3 Many of these factors can be evaluated, entirely or in part, during ground validation. Initial flyability checks should be conducted with software tools allowing the flyability of the procedure to be confirmed for a range of aircraft and in a full range of conditions (wind/temperature, etc.) for which the procedure is designed.

The verification of the flyability of an RNAV or RNP procedure can also include independent assessments by procedure designers and other experts using specialized software or full-flight simulators. Flyability tests using flight inspection aircraft can be considered, but it must be borne in mind that this only proves that the particular aircraft used for the test can execute the procedure correctly. This is probably acceptable for the majority of less complex procedures. The size and speed of flight test aircraft can seldom fully represent the performance of a fully loaded B747 or A340 and therefore simulation is considered the most appropriate way to carry out the flyability test.

Flight simulator tests should be conducted for those more complex procedures, such as RNP AR APCH, when there is any indication that flyability may be an issue.

Software tools that use digital terrain data (typically digital terrain elevation data (DTED) level 1 being required) are available to confirm appropriate theoretical navaid coverage.

4.3.5-Step 5- Implementation Decision

4.3.5.1 It is usually during the various validation processes described above that it becomes evident whether the proposed design can be implemented. The decision whether or not to go ahead with implementation needs to be made at a pre-determined point in the life cycle of a project.

Note. — If the available tools and/or quality of data used in Step 4 warrant, it may be desirable to undertake Step 6 before a final implementation decision is taken.

4.3.5.2 The decision of whether to go ahead with implementation will be based on certain deciding factors. These include:

a) whether the ATS route/procedure design meets air traffic and flight operations needs;
b) whether safety and navigation performance requirements have been satisfied;
c) pilot and controller training requirements; and
d) whether changes to flight plan processing, automation, or AIP publications are needed to support the implementation.

4.3.5.3 If all implementation criteria are satisfied, the project team needs to plan for execution of the implementation, not only as regards their “own” airspace and ANSP, but in cooperation with any affected parties which may include ANSPs in an adjacent State.

4.3.6 Step 6 — Flight inspection and flight validation

4.3.6.1 Flight inspection of navaids involves use of test aircraft which are specially equipped to gauge the actual coverage of the navaid infrastructure required to support the procedures, arrival and departure routes designed by the procedure design specialist.

Flight validation continues the procedure validation process noted in Step 4. It is used to confirm the validity of the terrain and obstruction data used to construct the procedure, and that the track definition takes the aircraft to the intended aiming point, as well as the other validation factors listed in Step 4.

4.3.6.2 Output from the above procedures may require the procedure design specialist to refine and improve the draft procedures. The *Manual on Testing of Radio Navigation Aids* (Doc 8071) provides general guidance on the extent of testing and inspection normally carried out to ensure that radio navigation systems meet the SARPs in Annex 10 —*Aeronautical Telecommunications*, Volume I. PANS-OPS (Doc 8168), Volume II, Part 1, Section 2, Chapter 4, Quality Assurance provides more detailed guidance on instrument flight procedure validation.

4.3.7 Step 7 — ATC system integration considerations

4.3.7.1 The new airspace concept may require changes to the ATC system interfaces and displays to ensure controllers have the necessary information on aircraft capabilities. Considerations arising from mixed equipage scenarios are discussed in Inset 7. Such changes could include, for example:

a) modifying the air traffic automation’s flight data processor (FDP);

b) making changes, if necessary, to the radar data processor (RDP);

c) requiring changes to the ATC situation display; and

d) requiring changes to ATC support tools.

4.3.7.2 There may be a requirement for changes to ANSP methods for issuing NOTAMS.

Inset 7 — Mixed navigation environments

A mixed navigation environment introduces some complexities for ATS. From an ATC workload and associated automation system perspective, the system needs to include the capability of filtering different navigation specifications from the ATC flight plan and conveying relevant information to controllers. For air traffic control, particularly under procedural control, different separation minima and route spacing are applied as a direct consequence of the navigation specification.

Mixed navigation environments usually occur in one of three scenarios:

a) One RNAV or one RNP application has been implemented (but not as a mandate), and conventional navigation is retained. An example of this would be if RNAV 1 were the declared RNAV specification for a terminal airspace, with the availability also of procedures based on conventional navigation, for those aircraft not approved for RNAV 1.

b) A "mixed-mandate" is used within an airspace volume — usually en-route or oceanic/remote procedural operations. For example, it is mandatory to be approved to an RNAV 1 specification for operation along one set of routes, and RNAV 5 along another set of routes within the same airspace.

c) A mix of RNAV or RNP applications is implemented in airspace, but there is no mandate for operators to be able to perform them. Conventional navigation could be authorized for aircraft that are not approved to any of the navigation specifications.

Mixed navigation environments can potentially have a negative impact on ATC workload, particularly in dense en-route or terminal area operations. The acceptability of a mixed navigation environment to ATC is also dependent on the complexity of the ATS route or SID and STAR route structure and upon availability and functionality of ATC support tools. The increased ATC workload normally resulting from mixed-mode operations has sometimes resulted in the need to limit mixed-mode operations to a maximum of two types, where there is one main level of capability. In some cases, ATC has only been able to accept a mixed environment where 90 per cent of the traffic is approved to the required navigation specification; whereas in other instances, a 70 per cent rate has been workable.

For these reasons, it is crucial that operations in a mixed navigation environment be properly assessed in order to determine the viability of such operations.

4.3.8 Step 8 — Awareness and training material

The introduction of PBN can involve considerable investment in terms of training, education and awareness material for both flight crew and controllers. In many States, training packages and computer-based training have been effectively used for some aspects of education and training. ICAO provides additional training material and seminars. Each navigation specification in Volume II, Parts B and C addresses the education and training appropriate for flight crew and controllers.

4.3.9 Step 9 — Establishing operational implementation date

An effective date will be set out in accordance with the requirements set out in Volume I, Attachment B, Data Processes. Experience has identified that an additional time period (e.g. one to two weeks) should be allocated prior to the operational implementation date. This additional period is to ensure ground and airborne system data are properly loaded and validated in databases.

4.3.10 Step 10 — Post-implementation review

4.3.10.1 After the implementation of PBN, the system needs to be monitored to ensure that safety of the system is maintained and to determine whether strategic objectives have been achieved. If after implementation, unforeseen events do occur, the project team should put mitigation measures in place as soon as possible. In exceptional circumstances, this could require the withdrawal of RNAV or RNP operations while specific problems are addressed.

4.3.10.2 A system safety assessment should be conducted after implementation and evidence collected to verify that the safety of the system is assured — *see the Safety Management Manual (SMM)* (Doc 9859).

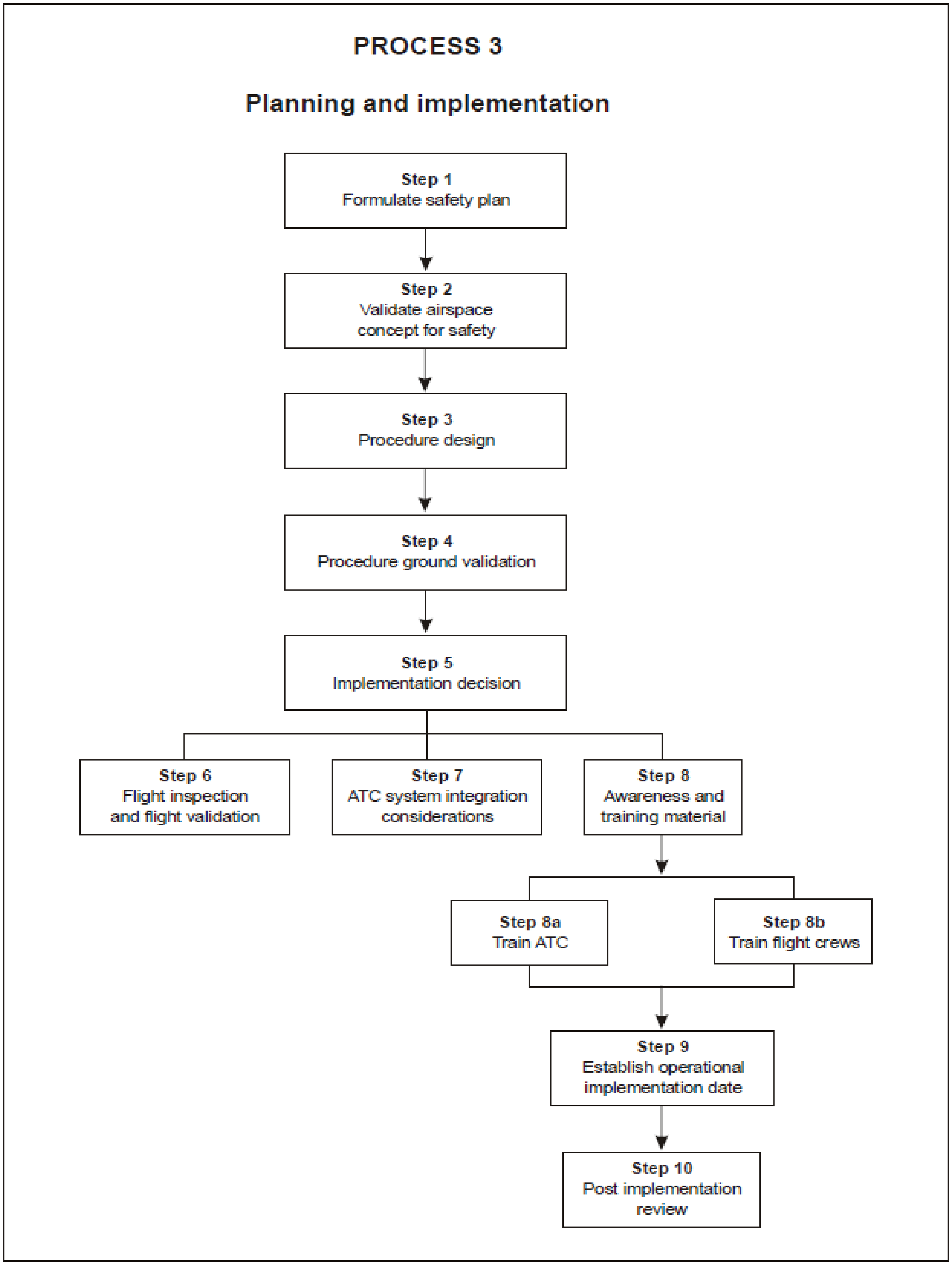

Figure I-B-4-1. Summary of Process 3

Director Flight Safety Services

Rwanda Civil Aviation Authority