




Implementation Processes

Process #3: Planning and Implementation

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Overview

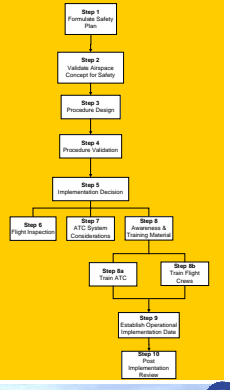
- Learning Objective: At the end of this presentation you should
 - Understand the inputs to Process 3
 - Generally comprehend the steps in Process 3
- This presentation will discuss
 - “Snapshot” of the 10 Steps of Planning and Implementation
 - Inputs to Process 3
 - Additional Considerations
 - Process 3: Step-by-Step Review

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Volume 1 Part B, Chapter 4: A Snapshot of Process #3




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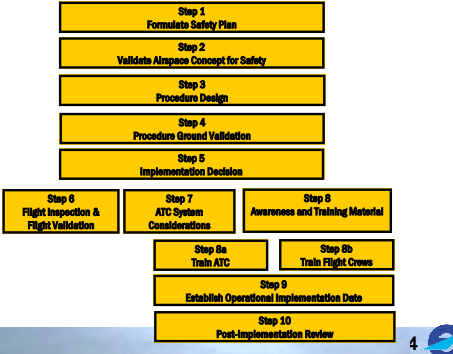
    graph TD
      S1[Step 1 Formulate Safety Plan] --> S2[Step 2 Validate Airspace Concept for Safety]
      S2 --> S3[Step 3 Procedure Design]
      S3 --> S4[Step 4 Procedure Validation]
      S4 --> S5[Step 5 Implementation Decision]
      S5 --> S6[Step 6 Flight Inspection]
      S5 --> S7[Step 7 ATC System Considerations]
      S5 --> S8[Step 8 Awareness & Training Material]
      S6 --> S9[Step 9 Establish Operational Implementation Date]
      S7 --> S9
      S8 --> S9
      S9 --> S10[Step 10 Post-Implementation Review]
  
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Process #3: Planning and Implementation



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Notes on Process 3

- The activities in Process 3 would be followed for any level of PBN implementation
 - A single instrument approach procedure
 - A set of terminal arrival and departure routes
 - A entire airspace redesign
- The activities described in Process 3 are not new – undertaken with any implementation

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Inputs to Process 3

- The navigation functional requirements, fleet capability, and CNS/ATM capabilities identified in Process 1
- The ICAO Navigation Specification(s) selected through Process 2
- Possible additional Region or State requirements for implementation should be identified and incorporated

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Review

Process 1:

Determine Requirements

Step 1
Formulate Airspace Concept


Step 2
Assess Existing Fleet Capability & NAVAID Infrastructure


Step 3
Assess Existing ATS Surveillance and Communications Infrastructure & ATM System

Step 4
Identify Necessary Navigation Performance and Functional Requirements

Step 5
Go to Process #2

PBN Manual Vol I, Part B, Chap 2

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Review

Process 2:

Identify ICAO Navigation Specification(s) for Implementation


Step 1
Review ICAO Navigation Specifications (Vol II)

Step 2
Identify the Appropriate ICAO Navigation Specification to Apply in the Specific CNS/ATM Environment

Step 3 (if Needed)
Identify Tradeoffs with Airspace Concept and/or Navigation Functional Requirements

Step 4
Select ICAO Navigation Specification(s)

PBN Manual Vol I, Part B, Chap 3

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Additional Considerations

- Possible regional or multi-regional agreements
 - For connectivity and continuity between airspaces
- If considering mandating a navigation specification, the decision needs to consider many factors, including:
 - Proportion of aircraft fleet capable of meeting requirements
 - Cost to operators to equip aircraft to meet requirements
 - Operational Impacts on
 - Operators
 - Flight crews
 - Air traffic services

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Step 1 Formulate Safety Plan

Remaining Slides: reference
PBN Manual Vol I, pgs B-4-1 through B-4-6

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Safety Plan


Formulate:

- What you will assess,
- How you will assess (methodology) and
- When (at what points in the process) you will assess

the safety of your planned implementation

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Safety Assessment

- Annex 11 and PANS-ATM require safety assessment when implementing a navigation specification
 - Simple airspace changes may not require extensive safety validation
- Consult ICAO Doc 9859 *Safety Management Manual*
- ICAO PBN Manual Volume II, Part A, Chapter 2 on *Safety Assessment* provides some detailed considerations for
 - Aircraft Performance
 - Aircraft RNAV System Failure
 - NAVAID Environment Failure
 - Air Traffic Surveillance, Communications Failures

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Safety Assessment: Key Guidance (1)

Annex 11
Air Traffic Services
Section 2.26.5


Any significant safety-related change to the ATC system, including implementation of a reduced separation minimum or a new procedure, shall only be effected after a safety assessment has demonstrated that an acceptable level of safety will be met and users have been consulted. When appropriate, the responsible authority shall ensure that adequate provision is made for post-implementation monitoring to verify that the defined level of safety continues to be met.


Note 1.— When, due to the nature of the change, the acceptable level of safety cannot be expressed in quantitative terms, the safety assessment may rely on operational judgment.



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Safety Assessment: Key Guidance (2)


ICAO Doc 4444
Procedures for Air Navigation Services-Air Traffic Management (PANS-ATM)


- ATS Safety Management (Chapter 2, Section 2.6)
 - 2.6.1.1 - A safety assessment shall be carried out in respect of proposals for significant airspace reorganizations, for significant changes in the provision of ATS procedures applicable to an airspace or an aerodrome, and for the introduction of new equipment, systems or facilities....
 - 2.6.1.2 - Proposals shall be implemented only when the assessment has shown that an acceptable level of safety will be met.



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Safety Assessment: Key Guidance (3)


ICAO Doc 9859
Safety Management Manual


- Safety Assessments (Chapter 13)
- The Three Fundamental Questions
 1. What could go wrong?
 2. What would be the consequences?
 3. How often is it likely to occur?
- Outlines 7 Steps for Safety Assessment



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Safety Assessment: Key Guidance (4)


ICAO Doc 9689
Manual on Airspace Planning Methodology for the Determination of Separation Minima


- Guidance to quantify effects of separation minima on air traffic safety
- Two Methods
 - **Target Level of Safety**
 - Acceptability criteria in assessing collision risk
 - Expressed as a statistical probability (e.g. 5×10^{-9} fatal accidents per flying hour)
 - **Comparative Assessment**
 - Can be used to analyze the differences between the existing and proposed systems



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Safety Assessment Considerations


ICAO Doc 9613
Manual on PBN
Volume II, Part A, Chapter 3


- Aircraft Performance
- RNAV System Failures
- Infrastructure
 - Failure of NAVAID environment
 - ATS surveillance and communication




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Step 2 Validate Airspace Concept for Safety



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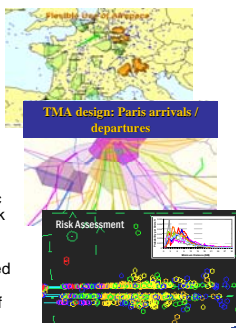
Purpose of Validation

- Validation of Safety of the Airspace Concept
 - Can also identify viability/non-viability of efficiency, effectiveness etc of alternatives
- Validation Means should be outlined in the Safety Assessment Plan
- Validation can involve the use of various means to determine if safety requirements are met
 - PBN Manual outlines 4 potential methods
- Validation process may identify additional requirements that will require adjustments to the Airspace Concept before it can be implemented

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Validation Methods (1)

- Airspace Modeling
 - Computer programs
 - Can eliminate non-viable alternatives
 - Quick evaluation of alternatives, changes to proposed routes, sectors etc
- Fast-Time Simulation
 - Computer simulations of air traffic can be used to conduct safety risk assessments
 - Safety risk assessments provide information concerning risks based on input from subject matter experts and statistical analyses of simulation model output




TMA design: Paris arrivals / departures

Risk Assessment

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Validation Methods (2)

- Real-Time Simulation
 - Most realistic means to validate an Airspace Concept
 - Simulators realistically replicate ATM operations
 - Require controller and "pseudo-pilot" participants
- Live ATC trials
 - Generally used to validate the most complex procedures or practices
 - Example: RNP (Authorization Required) Approach flight




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Step 3 Procedure Design

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Procedure Design (1)

- Procedure Design includes
 - ATS Routes (enroute, arrival, departure) and
 - Instrument Approach procedures
- Design criteria in ICAO Doc 8168 (Vol II) *Procedures for Air Navigation Services – Aircraft Operations (PANS OPS)*
- ICAO Doc 9905 (draft) *RNP AR Procedure Design Manual*
- PBN Manual Volume II *Navigation Specifications sections on Obstacle Clearance*



Aircraft Operations

3.2.3. Obstacle Clearance and Route Spacing
Obstacle clearance guidance is provided in PANS-OPS (ICAO Doc 8168, Vol II). The general criteria in Part 1 and Part 2 apply, together with the following additional specific criteria:

(i) RNAV-R

(ii) Where a GNSS infrastructure is provided, apply the criteria from Doc 8168, Volume II, Part II, Section 1, Chapter 3 and the chapter in Section 3 for the appropriate phase of flight.

(iii) Where a DME/DME Navaid infrastructure is provided apply the criteria for three-DME cover from Doc 8168, Volume II, Part II, Section 1, Chapter 3 and the chapter in Section 3 for the appropriate phase of flight. If the infrastructure does not support continuous DME/DME updating, consider loading the route on DME/DME/RU or expanding the route width to accommodate a gap in coverage.


(iv) Where both a GNSS and a DME/DME Navaid infrastructure are provided, apply the greater minima width from the two sets of minima.

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Procedure Design (2)
Database Coding: A Major Challenge

- Designers must ensure procedures can be coded into navigation databases in ARINC 424 format
 - Requires understanding differences in path terminator coding for aircraft RNAV systems
 - Overview in ICAO PBN Manual, Vol I, Attachment A "Area Navigation Systems"
 - Also see ICAO Doc 8168 PANS OPS Vol II, Chapter 5
- Cooperation with data base providers is essential
 - Many aircraft are equipped with RNAV systems that are only capable of using a sub-set of the available ARINC 424 path terminators


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Step 4 Procedure Ground Validation

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Procedure Ground Validation Objectives

- Design Criteria Compliance
- Verification of navigation data
- Verification of infrastructure
 - Runway markings
 - Airport lighting
 - Navigation signal sources
 - Communications
- Initial verification of procedure flyability
 - Software or simulator
- Evaluation of charting, operational factors

**Complements
similar objectives of
Flight Validation and
Flight Inspection**

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Procedure Ground Validation Quality Assurance (1)

- Quality Assurance is needed in each step of the procedure design process
- To ensure
 - Necessary levels of accuracy and integrity in data quality
 - Compliance with design criteria
 - Adequate mitigations in place if portions of criteria are waived

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Procedure Ground Validation Quality Assurance (2)


PANS OPS, Vol II Part 1, Section 2, Chapter 4 "Quality Assurance"

4.6.2. Ground validation is a review of the entire instrument flight procedure package by a person(s) trained in procedure design and with appropriate knowledge of flight validation issues.

- It is meant to catch errors in criteria and documentation, and evaluate on the ground, to the extent possible, those elements that will be evaluated in a flight validation.
- ...The ground validation will also determine if flight validation is needed for modifications and amendments to previously published procedures.

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Step 5 Implementation Decision

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Implementation Decision


**The Question:
Is the design of the route or procedure suitable?**

Considerations:

- ✓ Does it meet air traffic and flight operations needs?
- ✓ Does it meet safety & navigation performance requirements?
- ✓ Are there pilot and controller training requirements?
- ✓ Are changes to flight plan processing, automation, and aeronautical information publications needed?

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Implementation Decision

The Question:
Is the design of the route or procedure suitable?


YES → Plan to Execute


No → Redesign




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Step 6 Flight Inspection and Flight Validation



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ICAO Guidance Documents


**Doc 8168 PANS OPS, Vol II
Part 1, Section 2, Chapter 4 "Quality Assurance"**


**Doc 8071 Manual for the Testing of Radio Navigation Aids
Volume 2, Chapter 5**



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Flight Validation

PANS OPS, Vol II Part 1, Section 2, Chapter 4 "Quality Assurance"


4.6.3.1 ... The objectives of the flight validation of instrument flight procedures


- 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, is 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



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Flight Inspection

PANS OPS, Vol II Part 1, Section 2, Chapter 4 "Quality Assurance"


4.6.3.2 ..Flight validation should not be confused with flight inspection. Flight inspection of instrument flight procedures is required to assure that the appropriate radio navigation aids adequately support the procedure. This is carried out as part of a formal flight inspection programme and is performed by a qualified flight inspector using an appropriately equipped aircraft.








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Step 7 ATC System Considerations




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ATC System Integration (1)

- After procedure/route designs validated
- Implementation may require ATC system changes
 - Flight Data Processor
 - Radar Data Processor
 - Controller Display
 - Controller Support Tools
 - NOTAM Issuing Processes
- Need to account for extended timelines to implement and check system changes
 - Automation
 - Manual




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ATC System Integration (2)

- Additional integration challenges in a mixed aircraft equipage environment
 - Mixed equipage likely the common scenario for transition period
 - Systems need to accommodate both new navigation specifications and legacy conventional navigation
- Automation integration complexity increases
 - System needs to recognize different capabilities from flight plans
 - Convey this information to ATC
- Controller workload may increase in mixed equipage environment; factors include
 - Ratio of PBN-based to conventional aircraft loads
 - Complexity and commonality of route structures
- Need to limit implementation to what can be safely and efficiently managed
 - Phased implementation?




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**Step 8
Awareness and Training Material**

Step 8a
Train ATC

Step 8b
Train Flight Crews





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Awareness and Training (1)

- Every implementation requires some level of information to be provided to both controllers and flight crews
- Complexity of implementation drives type of information needed
 - Awareness
 - Education
 - Training

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Awareness and Training (2)

- Each Vol II Navigation Specification addresses knowledge and training for pilots and air traffic controllers

3.3.5. Pilot Knowledge and Training

The following items should be addressed in the pilot training program (for example, simulator, training device, or aircraft) for the aircraft's RNAV system.

a) The information in this chapter.

b) The meaning and proper use of Aircraft Equipment/Navigation Databases.

3.3.6. Controller Training

All traffic controllers who will provide RNAV terminal and approach control services in airports where RNAV 1 and RNAV 2 is implemented, should have completed training that covers the items listed below.

Core training

a) How area navigation systems work (in context of the navigation specification)

(i) Include functional capabilities and limitations of this navigation specification,

(ii) accuracy, integrity, availability and continuity

(iii) GPS receiver, RAIM, FDE, and integrity alerts,

(iv) waypoint fly-by vs. fly-over concept (and different turn performance)

Training Specific To The Navigation Specification

a) RNAV/STARs/DCAs

(i) related control procedures;

(ii) Radar vectoring Techniques;


(iii) open and closed STARs;

(iv) altitude constraints; and

(v) obstacle/clearance clearance;

b) RNP approach and related procedures;


c) RNAV 1 and RNAV 2 related terminology;



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**Step 9
Establish Implementation
Operational Date**



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Establish Operational Implementation Date


- Procedure/Route Airspace has been
 - ✓ Designed
 - ✓ Validated (ground; flight)
 - ✓ ATC System (automation, manual) changes supporting the implementation are set
 - ✓ Required aircrew and pilot awareness/training/education identified and conducted
 - ✓ Publication (charting, AIP) effective date established

What's Next?




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Establish Operational Implementation Date

- Experience has shown that an additional 1-2 weeks after publication effective date should be allocated before operational implementation of a new procedure ("turn-on") in the air traffic system
 - An additional period is a recommendation, not a requirement
 - Primarily for new procedure implementations, if there is any doubt that all participants will have the correct database information
 - Would need to ensure former procedures remain in data base until next publication cycle
- Additional period provides time to ensure ground and aircraft system data is correctly validated and loaded in data bases




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Step 10 Post-Implementation Review



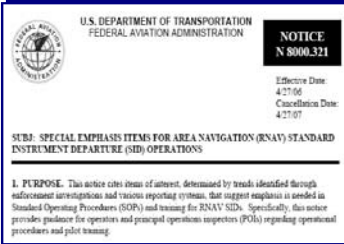
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Post-Implementation Review


- Monitor implementation to ensure
 - Safety is maintained
 - Expected benefits (capacity, efficiency, fuels savings etc) are being realized
- Implementation team may need to institute mitigations to address unforeseen issues






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Summary

- Process 3
 - 10 Steps for Planning and Implementation
- Formulate Safety Plan first
- Guidance materials for all steps in ICAO publications
 - ICAO Vol II PBN Manual has relevant material for each Navigation Specification
- Learning Objectives were
 - Understand the inputs to Process 3
 - Generally comprehend the steps in Process 3




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Audience Response System Questions



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Backup Slides

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7 Steps for Safety Assessment

- System description
- Hazard identification
- Estimation of hazard severity
- Estimation of the likelihood of the hazard occurring
- Evaluation of the risk
- Risk mitigation
- Development of safety assessment documentation

ICAO Doc 9859, *Safety Management Manual*, Chapter 13

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Aircraft Performance

- Normal performance
 - Lateral accuracy is expressed in terms of nautical miles either side of a desired track centerline
 - Aircraft is expected to be within the lateral value of the desired track centerline at least 95% of the time
- Non-Normal Errors:
 - Some non-normal errors are addressed by on-board performance monitoring and alerting requirements
 - “Blunder” type errors (e.g. selection of wrong route) are not included in on-board performance monitoring and alerting requirements
 - Handled through training, surveillance detection or additional separation

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RNAV System Failures (1)

- Aircraft having single navigation systems (where allowed) must be considered in the safety assessment
- Potential mitigations are identified by considering:
 - Nature of aircraft system failure
 - Availability of alternate navigation
 - Available CNS/ATM environment

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RNAV System Failures (2)

- In a Surveillance environment
 - One aircraft with failure of navigation capability could be handled
- In an Non-surveillance environment
 - Complete navigation system failure and unreported position errors must be considered
 - Potential mitigations are identified by considering:
 - Nature of aircraft system failure
 - Availability of alternate navigation and CNS/ATM environment

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Failure of Navigation Aid Environment

- NAVAID infrastructure and the degree of redundancy needs study
 - Inertial navigation should be considered as a mitigation for areas with sparse NAVAID infrastructure
- Where GNSS is the predominant positioning source:
 - Likelihood of GNSS outage must be considered
 - If mitigation is ATS surveillance
 - ATC workload must be considered
 - Aircraft carriage of alternate navigation capability must be considered if ATS surveillance not feasible

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ATS Surveillance and Communication

- Consider the contribution of ATS surveillance and communications as mitigation to achieve TLS for a desired route or spacing
- Availability of ATS surveillance along route to support TLS
- Effectiveness of ATC intervention when aircraft fail to maintain route center line should be considered
- ATS communication requirement is VHF
 - Exception in remote and oceanic airspace (HF, SATCOM, CPDLC)
 - Consider Reception Strength

