Implementation Processes

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

1. Formulate Safety Plan
2. Validate Airspace Concept for Safety
3. Procedure Design
4. Procedure Validation
5. Implementation Decision
6. Flight Inspection
7. ATC System Considerations
8. Awareness & Training Material
   a. Train ATC
   b. Train Flight Crews
9. Establish Operational Implementation Date
10. Post Implementation Review
Process #3: Planning and Implementation

Step 1
Formulate Safety Plan

Step 2
Validate Airspace Concept for Safety

Step 3
Procedure Design

Step 4
Procedure Ground Validation

Step 5
Implementation Decision

Step 6
Flight Inspection & Flight Validation

Step 7
ATC System Considerations

Step 8
Awareness and Training Material

Step 8a
Train ATC

Step 8b
Train Flight Crews

Step 9
Establish Operational Implementation Date

Step 10
Post-Implementation Review
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
Additional Considerations

• Possible regional or multi-regional agreements
  – Connectivity and continuity between airspaces

• Possible mandate of a navigation specification:
  – 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
Step 1
Formulate Safety Plan
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
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.
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.
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
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. $5 \times 10^{-9}$ fatal accidents per flying hour)
  - Comparative Assessment
    - Can be used to analyze the differences between the existing and proposed systems
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
Step 2
Validate Airspace Concept for Safety
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
Validation Methods (1)

- **Airspace Modeling**
  - Computer programs that can eliminate non-viable Airspace Concept alternatives
  - Allows quick evaluation of alternatives and changes to proposed ATS 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
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
Step 3
Procedure Design
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)*
  - RNP AR APCH design criteria in *ICAO Manual for RNP AR Approach*
- Also see PBN Manual Volume II Navigation Specifications sections on Obstacle Clearance
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
    ➢ 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
Step 4
Procedure Ground Validation
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
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
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.
The Question:
Is the design of the route or procedure suitable?

Factors in the decision:
✓ 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?
Implementation Decision

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

YES ➔ Plan to Execute

No ➔ Redesign
Step 6
Flight Inspection
and
Flight Validation
ICAO Guidance Documents

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

Volume 2, Chapter 5
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

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.
Step 7
ATC System Considerations
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
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 increases; 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?
Step 8
Awareness and Training Material

Step 8a
Train ATC

Step 8b
Train Flight Crews
• 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
• Each Vol II Navigation Specification addresses knowledge and training for pilots and air traffic controllers.

### Awareness and Training (2)

#### 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.

- The information in this chapter.
- The meaning and proper use of Aircraft Equipment/Navigation Suffixes.
- Procedure characteristics as determined from chart depiction and textual description.

#### 3.2.6. Controller Training

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

**Core training**

- How area navigation systems work (in context of this navigation specification)
  - Include functional capabilities and limitations of this navigation specification,
  - accuracy, integrity, availability and continuity
  - GPS receiver, RAIM, FDE, and integrity alerts;
  - waypoint fly-by vs. fly-over concept (and different turn performance)

**Training Specific To This Navigation Specification**

- RNAV STARs, SIDs:
  - related control procedures;
  - Radar Vectoring Techniques;
  - open and closed STARs;
  - altitude constraints; and
  - descend/climb clearances;
- RNP approach and related procedures;
- RNAV 1 and RNAV 2 related phraseology;
- Impact of requesting a change to courses during a procedure.
Step 9
Establish Implementation Operational Date
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?
Establish Operational Implementation Date

- Experience has shown that an additional 1-2 weeks after publication effective date should be allocated before operational implementation ("turn-on") in the air traffic system.
- Additional period provides time to ensure ground and aircraft system data is correctly validated and loaded in data bases.
Step 10
Post-Implementation Review
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
Summary

- **Process 3**
  - 10 Steps for Planning and Implementation
- **Safety Assessment (Safety Case) 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
Bearing in mind the target audience in ICAO Regions

Feedback and Questions
Backup Slides
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

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
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
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
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
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