International Civil Aviation Organization

Eleventh Meeting of the Air Traffic Management Sub-Group (ATM/SG/11) of APANPIRG

Singapore, 2 – 6 October 2023

Agenda Item 8: Any other business

BRIEFING ON INTERVAL MANAGEMENT

(Presented by Singapore)

SUMMARY

This paper provides a briefing on the concept of Interval Management.

1. INTRODUCTION

1.1 There are several applications that are supported by ADS-B In. These include the Cockpit Display of Traffic Information (CDTI)-Assisted Visual Separation (CAVS), CDTI-Assisted Separation on Approach (CAS-A) and Interval Management (IM).

1.2 The Surveillance Panel is working on guidance material to address the technical aspects of these applications.

1.3 This paper provides a brief on IM.

2. DISCUSSION

Concept of Interval Management

2.1 IM consists of a set of ground and flight-deck capabilities used in combination by air traffic controllers and flight crew to achieve a precise interval more efficiently between aircraft in a stream of traffic. It requires ADS-B Out and ADS-B In equipage.

2.2 During operations, the controller will instruct flight crew to achieve and maintain an assigned spacing goal (time or distance) relative to another aircraft.

2.3 The flight crew will use the Flightdeck IM (FIM) avionics to manage aircraft speed to achieve the instructed ATC objective.

2.4 Operations approval from the State of Registry is required before IM can be carried out.

Procedures

2.5 Using the ATM automation system, ATC will determine IM aircraft pairs and desired spacing goals. ATC will then communicate Lead Aircraft identification and IM initiation parameters to the IM aircraft flight crew.

2.6 Flight crew of the IM aircraft will enter the information into the FIM avionics. When the IM execution requirements are met, the FIM avionics provides IM speeds for flight crew to fly and maintain the desired spacing.

2.7 Flight crew will follow the IM speeds while ATC will monitor until termination of the IM procedure.

Benefits

2.8 The precise management of intervals between aircraft with common or merging trajectories, maximises airspace throughput while reducing ATC workload along with more efficient aircraft fuel burn reducing environmental impact.

2.9 In terms of punctuality, IM will improve consistent spacing precision by making more frequent speed adjustments than is possible with a ground system alone.

2.10 In terms of safety, IM will improve separation provision at a planning horizon by ensuring that spacing is always greater than the minimum separation.

Applicable Standards

2.11 FIM Minimum Operational Performance Standards (MOPS) (DO-361) was published in November 2015. DO-361A was published in March 2020. Future editions due to refinements are expected.

2.12 Thus far, there are no avionics products that fully meet DO-361. However, trials (known as Initial – Interval Management) are being carried out by the FAA using avionics that meets some of the requirements.

Further work by ICAO

2.13 Additional guidance material or improvement on existing material will be expected on ICAO Annex 10 Vol IV, ICAO Doc 9994 Manual on Airborne Surveillance Applications, ICAO Doc 4444 PANS ATM and ICAO Doc 8168 PANS-OPS Vol III.

Acknowledgements

2.14 The material presented in this paper are extracted from WP04 at the 14th meeting of the Surveillance Panel-Airborne Surveillance Working Group. The slides from the Surveillance Panel are attached in **Annex A**.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) note the information contained in this paper; and

b) discuss any relevant matters as appropriate.

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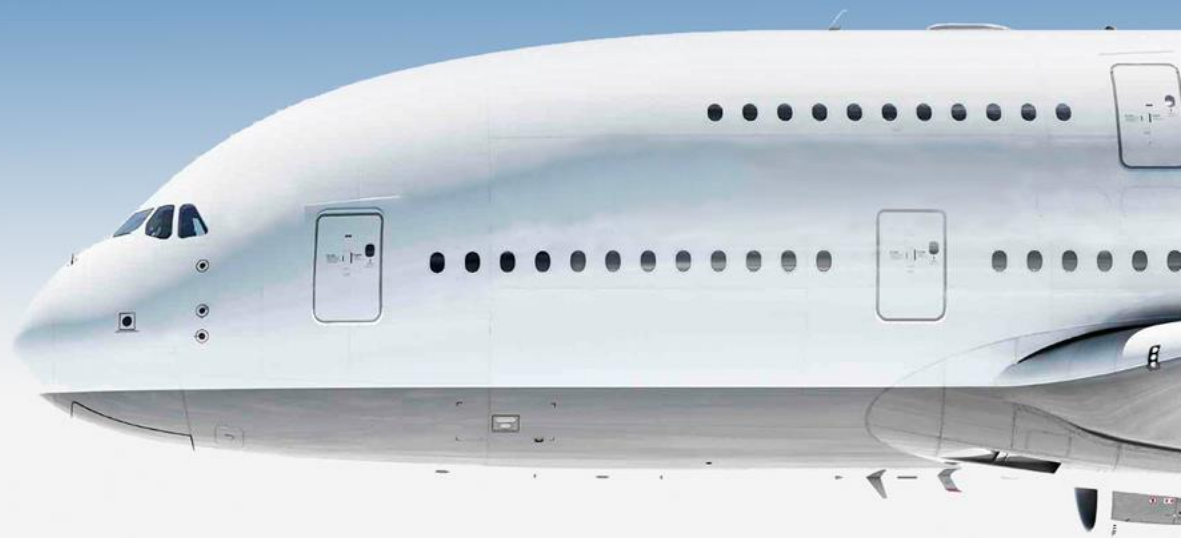
ICAO UNITING AVIATION

SP-AIRB WG – IM Procedure briefing



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ADS-B-In Capability: Interval Management (IM)

- Interval Management (IM) consists of a set of ground and flight-deck capabilities used in combination by air traffic controllers and flight crews to more efficiently achieve a precise interval between aircraft in a stream of traffic
- Reducing inter-aircraft spacing variance will yield more efficient use of runway capacity while also enabling aircraft to remain on their Performance-based Navigation (PBN) procedures more frequently
- IM functionality requires ADS-B Out (all versions) and ADS-B In equipage

Operational Concept

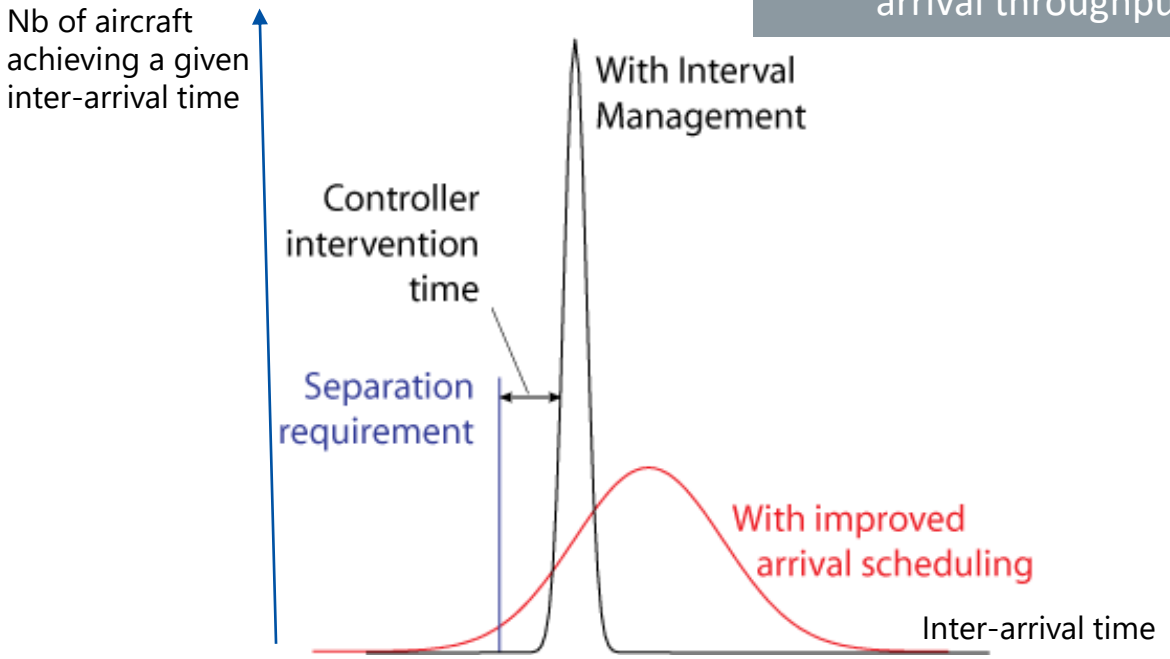
- Controller instructs flight crew to achieve / maintain an assigned spacing goal (time or distance) relative to another aircraft
- Flight crew uses FIM avionics to manage aircraft speed to achieve instructed ATC objective.
- FIM stands for Flight deck IM and refers to IM equipment on board.

To see the IM storyboard animation, go to https://www.faa.gov/about/office_org/headquarters_offices/ang/offices/tc/library/Storyboard/detailedwebpages/im.html

IM concept overview

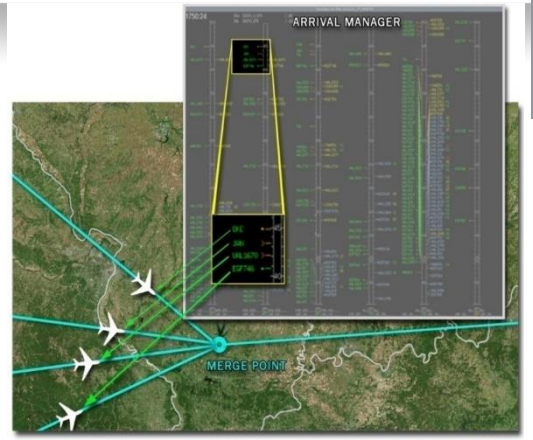
- Enabled by ADS-B In, Interval Management (IM) will facilitate more precise inter-aircraft spacing
- IM avionics onboard an aircraft will provide speed commands to the flight crew to achieve an Assigned Spacing Goal relative to a Target Aircraft
  - IM is a **tactical** spacing tool
  - ATC provides the spacing goal, which can be based on a metering schedule, miles-in-trail restriction, applicable separation standard, or any other operationally-needed spacing objective
  - **Improves spacing consistency** by enabling more frequent speed adjustments than possible with a ground system alone

More precise spacing can be translated into increased arrival throughput

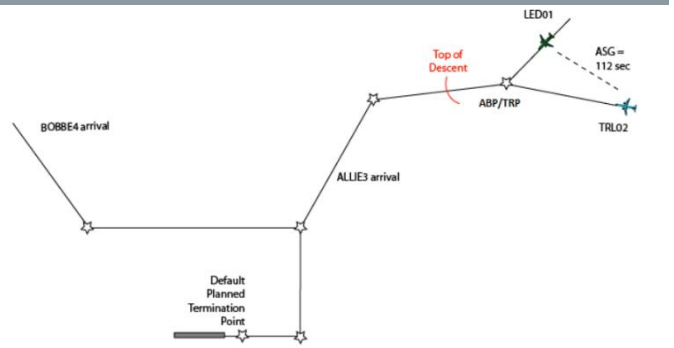


General IM procedure

ATC utilizes ground automation capabilities to pre-condition arrival flows

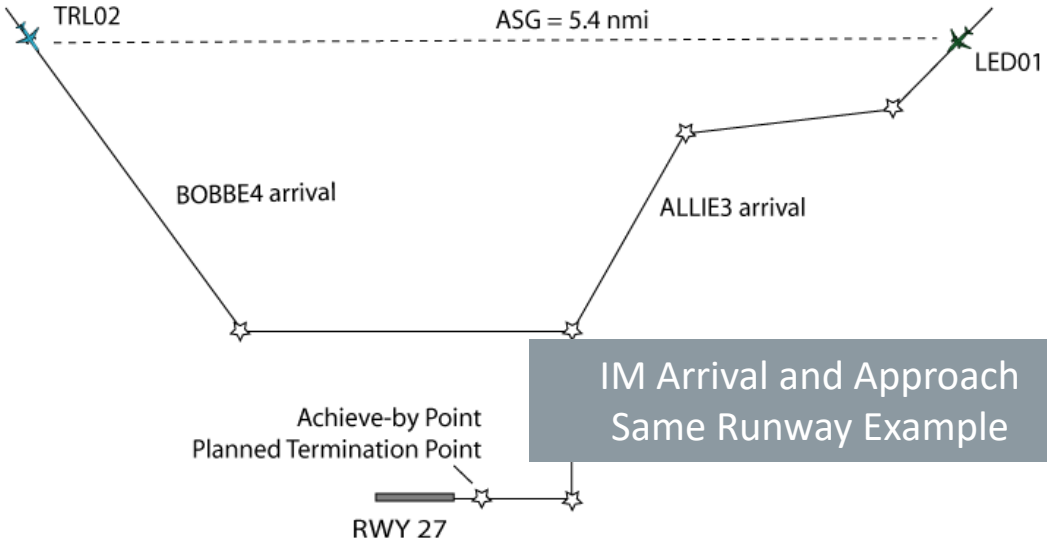


IM Arrival and Approach High altitude merge Example



Spacing Goal = 80 seconds

- Assisted by ground automation, ATC determines IM aircraft pairs and desired spacing goals
- ATC communicates Lead Aircraft identification and IM initiation parameters to the IM Aircraft flight crew
- Flight crew of IM Aircraft enters the information into FIM avionics
- When IM execution requirements are met, FIM avionics provides IM Speeds for flight crew to fly to achieve and/or maintain desired spacing
- Flight crew follows the IM Speeds and ATC monitors until termination



IM Arrival and Approach Same Runway Example

IM operational benefits

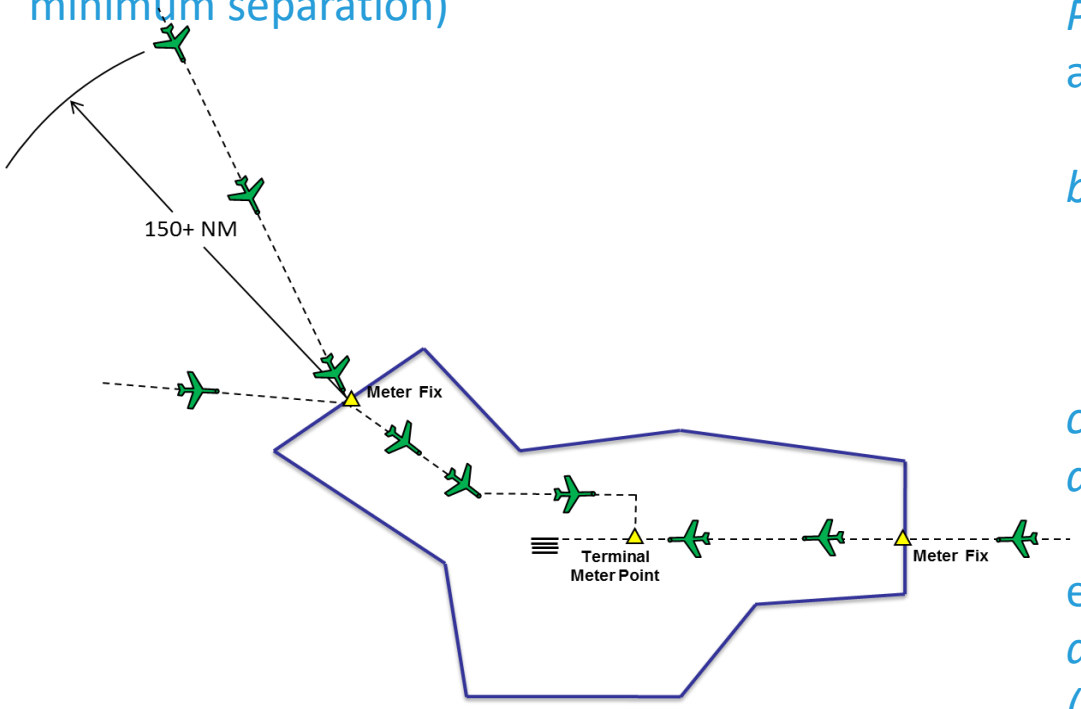
There are direct Benefits to ANSP, Aircraft Operator and airport operators:

The precise management of intervals between aircraft with common or merging trajectories, **maximizes airspace throughput** while **reducing ATC workload** along with **more efficient aircraft fuel burn reducing environmental impact**.

Punctuality: IM will improve consistent spacing precision by making more frequent speed adjustments than is possible with a ground system alone.

Reduction of flight time variability

Safety: IM will improve separation provision at a planning horizon (by ensuring that spacing is always greater than the minimum separation)



Potential benefits of IM operations include

a) Timely speed advisories *removing* later requirement for *path-lengthening;*

b) Consistent and low variance *spacing between paired aircraft* (e.g. at the entry to an arrival procedure and on final approach). *More precise spacing can allow for higher throughput and more efficient aircraft operations*;

c) Optimized descent profile in high density environments;

d) Reduced ATC instructions due to the reduced number of speed instructions; and

e) *More efficient aircraft operations for FIM-equipped aircraft, when aircraft are pre-sequenced, e.g., with the use of an arrival manager (AMAN).*

IM operational benefits

- Can we identify the main IM benefits for stakeholders?

ANSP
- Reduced ATCO workload at APP/TWR position
- Reduced R/T
- Improved predictability/punctuality

Aircraft Operators
- Reduced R/T in final phase
- Improved predictability (less radar vectoring)
- Increased opportunities for optimized descent and less fuel burn

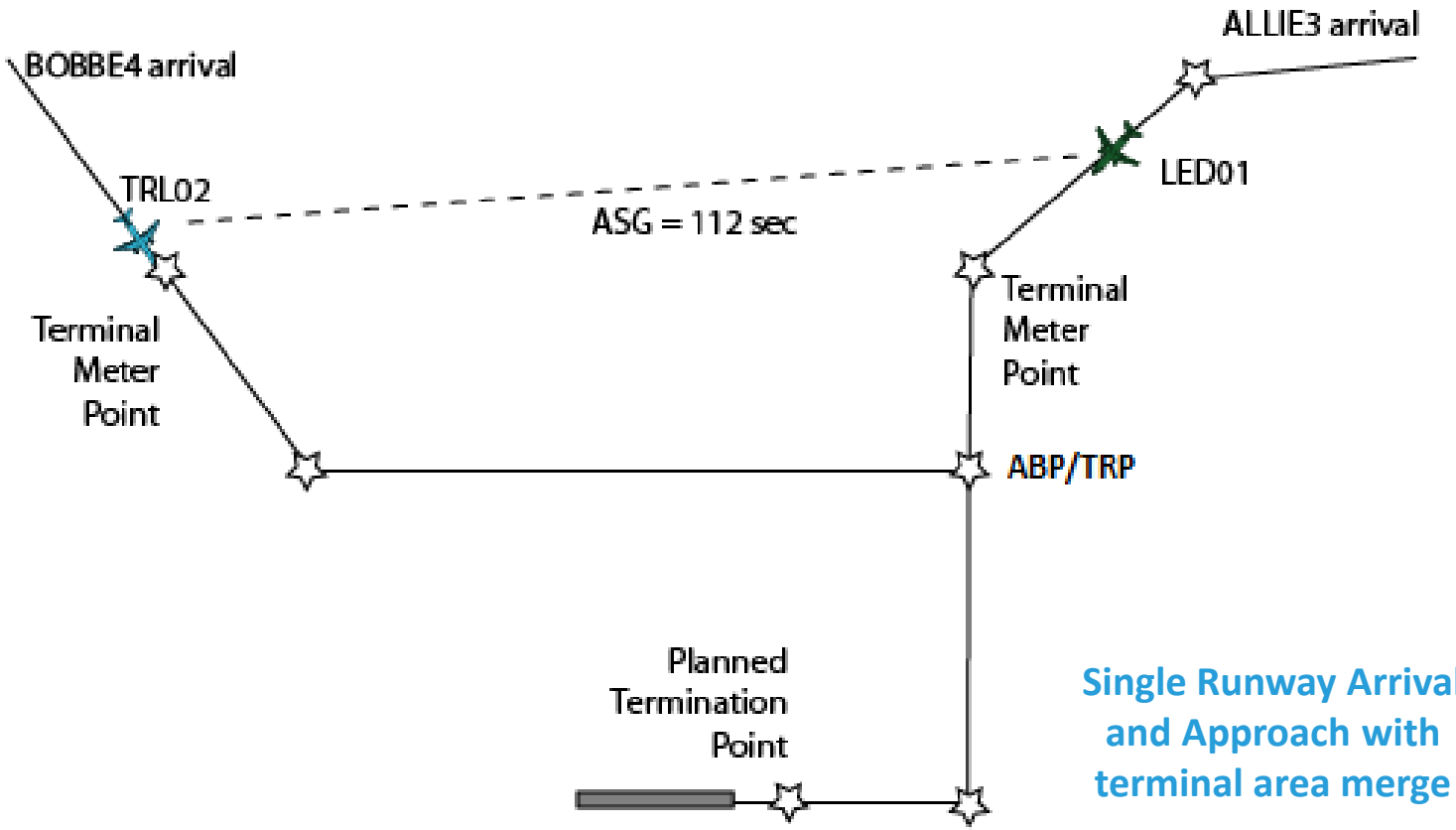
Airport Operators
- Improved predictability/punctuality of arrivals
- Potential increase of runway throughput (or hub sequence)

IM operating environments

En route through terminal: to a single runway during metering operations (~TOD to no later than the final approach fix)

- Ground automation schedules IM-capable aircraft closer than it would otherwise
- IM operations can start before aircraft are on common routes, though IM and Target routes must be common at last waypoint
- Ground automation sets up feasible IM operations based on ETAs to the Achieve-by Point
- Aircraft are on RNAV routes with altitude and speed constraints (4D trajectory)

IM Arrival and Approach (Same Runway)



Single Runway Arrival and Approach with terminal area merge

IM Avionics - Standards

IM Avionics Standards include:

- Input/Output (I/O) requirements
- Internal processing requirements
- Test procedures and test vectors
- A sample algorithm that meets the requirements

Flight-deck Interval Management (FIM) Minimum Operational Performance Standards (MOPS) (DO-361) – published Nov 2015

- Same runway applications, federated avionics
- Recent flight tests by NASA & NLR using prototype avionics which meet many (but not all) DO-361 requirements

DO-361A published in March 2020

- Adds dependent runway applications, integration with data communications

IM clearance

IM Clearance Information

To initiate and execute an IM operation, ATC needs to communicate the following information to the flight crew:

- IM Clearance Type (e.g., Achieve-by then Maintain vs. Capture then Maintain)
- Lead Aircraft ID
- Assigned Spacing Goal
- Achieve-by Point (when applicable)
- Lead Aircraft Intended Flight Path Information (IFPI) (when applicable)
- Planned Termination Point (may be defaulted)

Lead Aircraft IFPI can be specified as a combination of the following:

- Same route (as the IM Aircraft)
- Direct-to a named waypoint
- Named route (e.g., a RNAV STAR or approach)

IM Avionics - algorithm

Algorithm Functionality and Equipage

- **IM Avionics algorithm is predictive (i.e., based on predicted 4D trajectories for both IM and Lead Aircraft)**
  - IM Speeds are relative to a nominal speed profile (limited to ±15% of the nominal speeds and based on procedural speed constraints)
  - Lead Aircraft's winds can be derived from IM Aircraft's winds or be provided separately
  - Lead Aircraft's IFPI must be sufficiently constrained with altitude and speed constraints to ensure a reasonable prediction of the Lead's trajectory in the algorithm

- **Avionics implementation**
  - Initial implementation: FIM not integrated with other flight-deck systems (e.g., FMS, flight guidance, or Data Comm systems), flight crew implements IM Speeds manually and ensures that aircraft is able to meet altitude constraints on the RNAV procedures. However, FIM avionics need to have access to published arrival and approach procedures for the implementing airspace (e.g., TMA).
  - Enhanced implementation: FIM avionics potentially integrated with data communications, FMS, and flight guidance systems
  - Details should be provided by aircraft manufacturers and avionics suppliers

Published ADS-B-In Avionics Standards

- Oceanic In-Trail Procedures (ITP) SPR
  RTCA DO-312 / EUROCAE ED-159 - 2012
- Visual Separation on Approach (VSA) SPR
  RTCA DO-314 / EUROCAE ED-160 - 2008
- Airborne Traffic Situational Awareness (AIRB) SPR
  RTCA DO-319 / EUROCAE ED-164 - 2010
- Surface Traffic Situational Awareness (SURF) SPR
  RTCA DO-322 / EUROCAE ED-165 - 2010
- Traffic Situation Awareness with Alerts (TSAA) SPR
  RTCA DO-348 / EUROCAE ED-232 [referred to as ADS-B Traffic Awareness System (ATAS)] - 2014
- CDTI-Assisted Visual Separation (CAVS) SPR
  SPR, RTCA DO-354 / EUROCAE ED-233 - 2014
- Aircraft Surveillance System (ASA) MOPS, RTCA DO-317C / EUROCAE ED-194B
  - Requirements for AIRB, SURF, VSA, CAVS, ATAS, and ITP - 2020
- **Interval Management (IM) SPR**
  RTCA DO-328A / EUROCAE ED-195A - 2020
- **Interval Management (IM) MOPS, RTCA DO-361A / EUROCAE ED-236A - 2020**

SPR = Safety, Performance, and interoperability Requirements

MOPS = Minimum Operational Performance Standards

IM and ground-based automation

- **En route and terminal tactical IM operations may be possible with nothing more than an indication of IM equipage on the controller display**
  - FIM capability is expected to be indicated in the flight plan
- **Capabilities for ground automation are being designed to perform the following functions:**
  - Precondition arrival flows for increased probability of successful IM Operations
  - Account for IM and Lead Aircraft capability when building an arrival schedule
  - Identify aircraft pairs and clearance information elements
  - Determine initial feasibility of the IM Operation
  - Generate a clearance appropriate for voice communications
  - Provide IM initiation information to the controller(s), including when the IM and Lead Aircraft are in different sectors
  - Provide IM monitoring information to the controller(s), including IM current state

Operational Approval

Proposed guidance (extracts of Doc 9994)

Operational approval is required for the pilots and the aircraft to perform IM.

As a means to harmonize operational approvals, States are encouraged to require a standard set of information to be submitted by the operator for review by the regulator prior to issuance of the operational approval.

Recommended information to be provided includes:

a) intended areas of IM operations;

b) the certification basis of the FIM equipment (e.g., Technical Standard Order) attesting to compliance with an applicable FIM standard;

c) FIM equipment system description, operating procedures and abnormal indications;

d) pilot training content and method of training;

e) flight planning requirements and documentation;

f) relevant portions of the minimum equipment list (MEL) for FIM equipment;

g) maintenance return to service requirements and training requirements for the FIM equipment;

h) instructions for continued airworthiness of the FIM equipment;

i) relevant portions of the operations manual.

Operational Approval

IM qualification Evaluation Sample checklist

Requirement	Description	✓
Airspace of IM operations	Does the documentation list the intended airspace of IM operations? Does the documentation show compliance with ANSP requirements to conduct IM operations?	
Certification basis of FIM equipment	Does documentation show compliance with an applicable FIM standard? Does the FIM equipment qualify for use in the airspace of intended IM operations?	
FIM equipment system description, operating procedures and abnormal indications	Does documentation include FIM system description, pilot operating procedures and explanation of abnormal indications?	
Pilot training content	Does pilot training material suitably contain all elements specified in paragraph 4.7.2.2.1.2?	
Method of training	Does submitted documentation describe the method of pilot training? Is the method of training suitable for the complexity of the proposed IM operation and FIM equipment?	
Flight planning	Does the flight planning document properly describe FIM equipage and capability codes for fields 10b and 18? Does it comply with ICAO PANS-ATM?	
FIM Minimum Equipment List	Are relevant portions of the minimum equipment list for FIM equipment provided? Does the MEL documentation include operator actions to perform with respect to flight plan codes in the event of inoperative FIM equipment?	
Maintenance	Do the maintenance return to service requirements and maintenance training requirements for the FIM equipment comply with manufacturer's recommendations?	
Airworthiness	Does the documentation include the avionics manufacturer's instructions for continued airworthiness of the FIM equipment?	
Operations manual	Are relevant portions of the operations manual, or other operational approval document provided? Does the manual, or other appropriate document describe IM as an approved operation for the aircraft type? Note: Each State may have a different means to document operational approval.	

Envisaged changes to provisions

ICAO Annex 6

- No need for changes. (There is no intention to propose a mandatory carriage of IM)

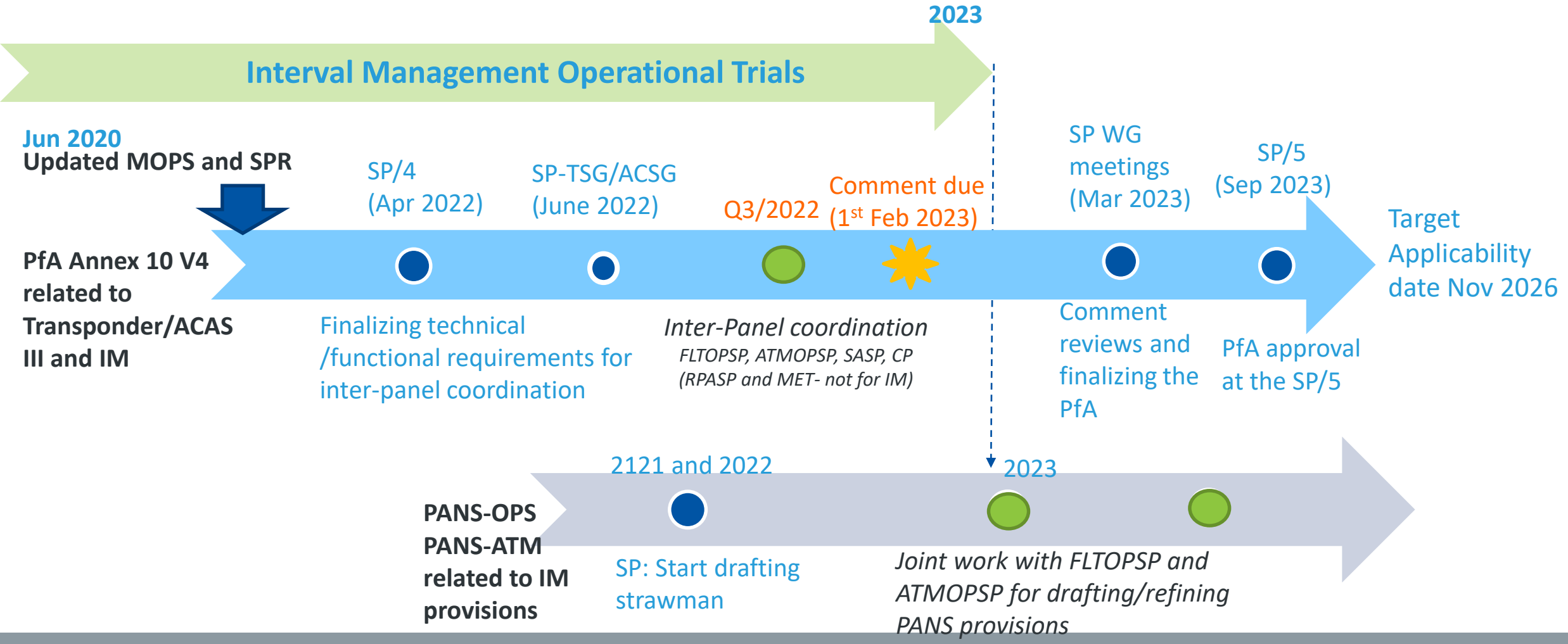
ICAO Doc 4444 PANS ATM

- No change in separation responsibility and/or minima
- Draft phraseology for Chapter 12 exists but subject to operational trials
- Suitable chapter for IM description to be determined
- Drafting of additional provision proposals is postponed until results of the operational validation in the U.S. can be expected (not prior 2023)

ICAO Doc 8168 PANS-OPS Vol III

- New “Chapter 2 - Operation of Interval Management (IM)” proposed in Section 8
- Contents: General, Requirements, IM Procedure, FIM avionics and Aeroplane Operating Procedures
- Draft text as input to be updated with the results of operational validation

SARPs and Guidance material for Interval Management (IM)



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