PBN TRAINING FOR AIR TRAFFIC CONTROLLERS

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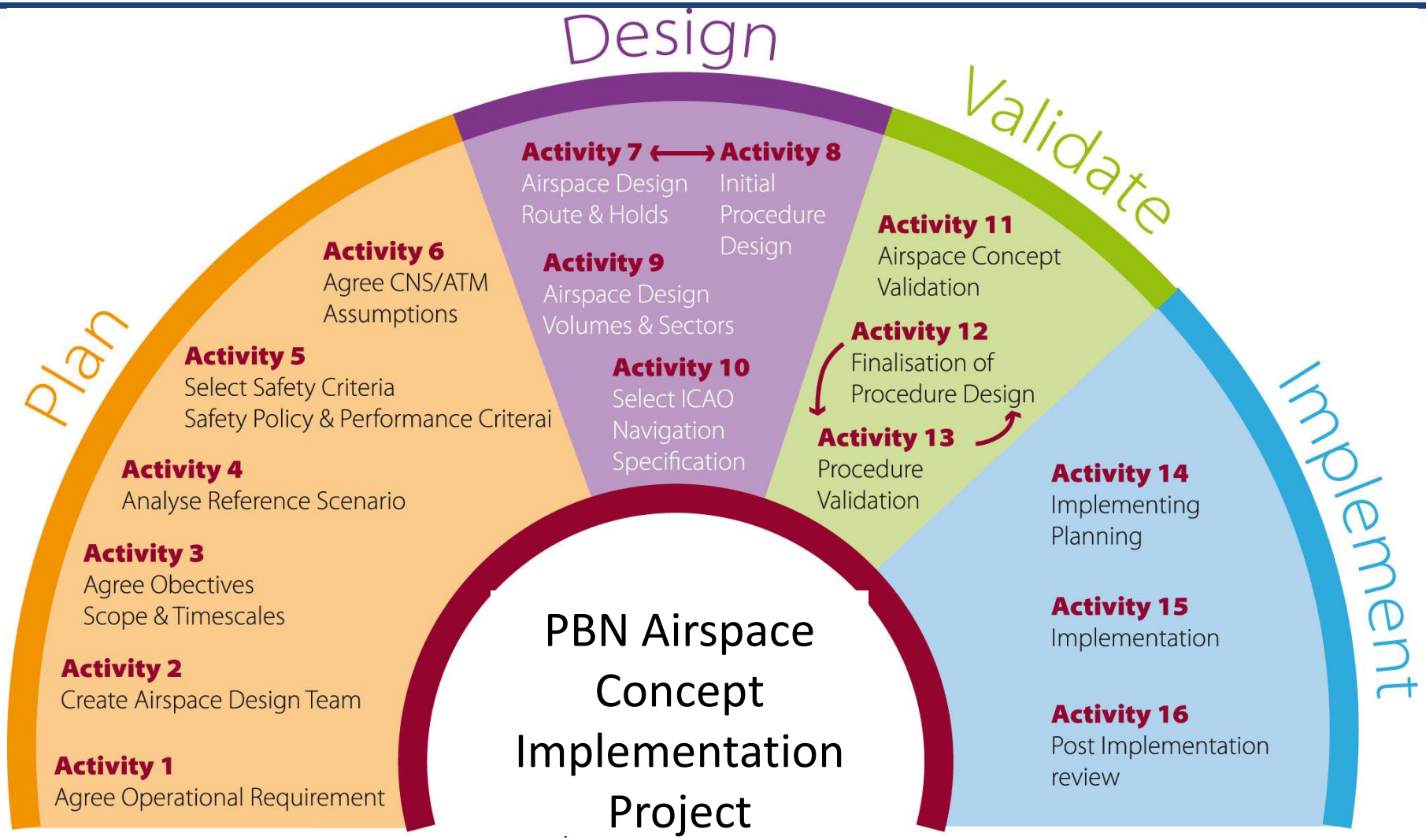
RO ATM/SAR
International Civil Aviation Organization

PBN Project


Design
Validate
Plan
Implement
Activity 7 ⟷ Activity 8
Airspace Design Route & Holds
Initial Procedure Design
Activity 6
Agree CNS/ATM Assumptions
Activity 9
Airspace Design Volumes & Sectors
Activity 11
Airspace Concept Validation
Activity 5
Select Safety Criteria
Safety Policy & Performance Criterai
Activity 10
Select ICAO Navigation Specification
Activity 12
Finalisation of Procedure Design
Activity 13
Procedure Validation
Activity 4
Analyse Reference Scenario
Activity 14
Implementing Planning
Activity 3
Agree Obectives
Scope & Timescales
Activity 15
Implementation
Activity 2
Create Airspace Design Team
Activity 16
Post Implementation review
Activity 1
Agree Operational Requirement
PBN Airspace Concept Implementation Project

Implementation Phase Considerations

- Implementation Date decision
- PRE IMPLEMENTATION REVIEW
  - ATS LOAs and other considerations
  - TRAINING
  - AIP / AIRAC

AIRSPACE BY AREA OF OPERATION

- **Oceanic and remote continental**

- RNAV 10 (RNP 10), RNP 4 and RNP 2 rely primarily on GNSS and may require ATS surveillance for certain applications.

- **Continental en route**

- RNAV 5 and RNP 2 applications are expected.

AIRSPACE BY AREA OF OPERATION

Terminal airspace: arrival and departure

- Include arrival and departure supported by RNAV applications and RNP 2 and 1 application in non-radar, low-density terminal airspace.

Approach

- Approach concepts cover all segments of the instrument approach, i.e. initial, intermediate, final and missed approach. These include RNP specifications requiring a navigation accuracy of 0.3 NM to 0.1 NM or lower.

- Three sorts of RNP applications are characteristic of this phase of flight: RNP APCH and RNP AR APCH as well as A-RNP.

PBN Training

Programme

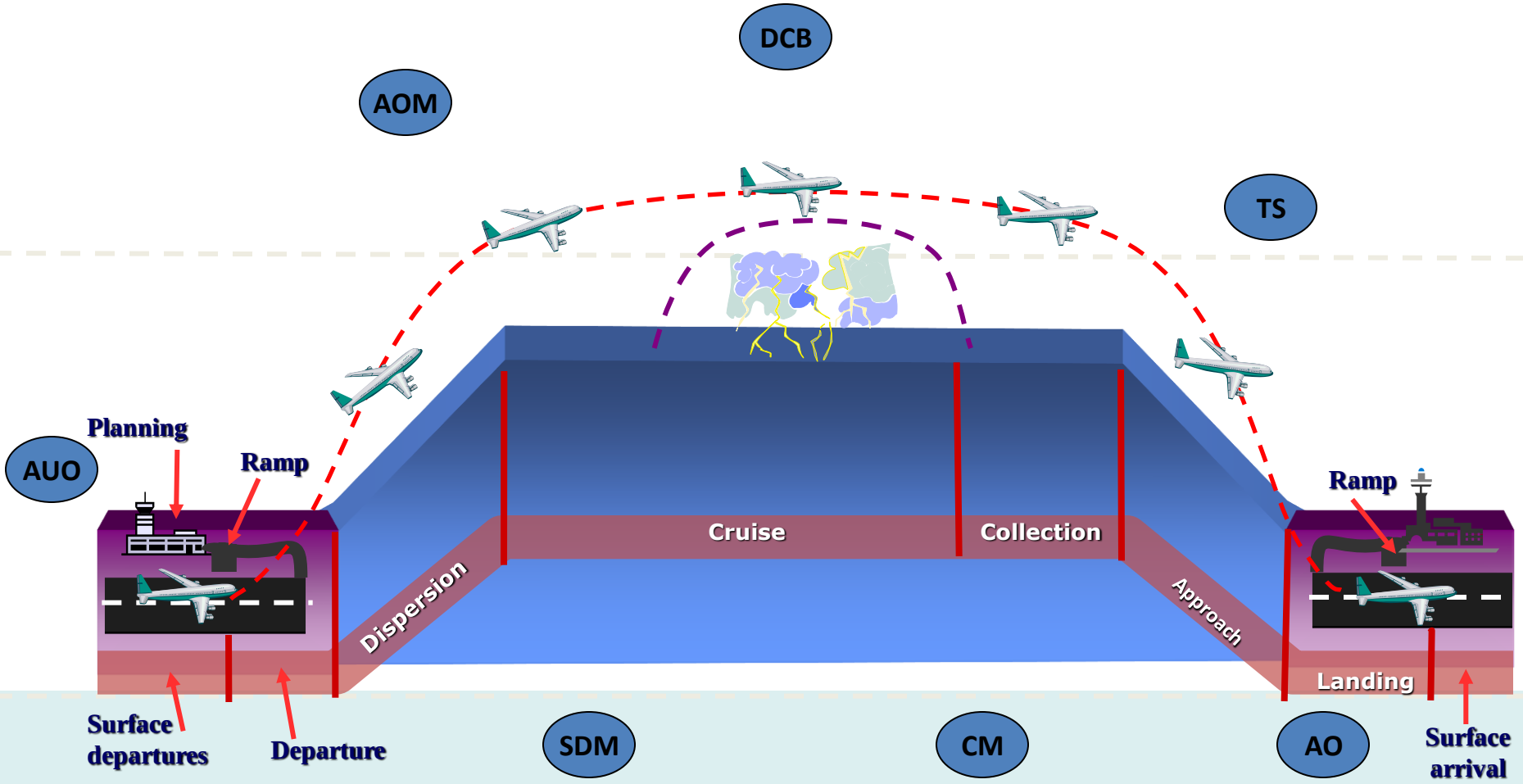
- BASIC
- RECURRENT
- ADVANCED

Topics

- ENROUTE
  - OCEANIC
  - CONTINENTAL
- TERMINAL
- APPROACH

Gate to Gate concept

Phases of flight (Doc 9854)



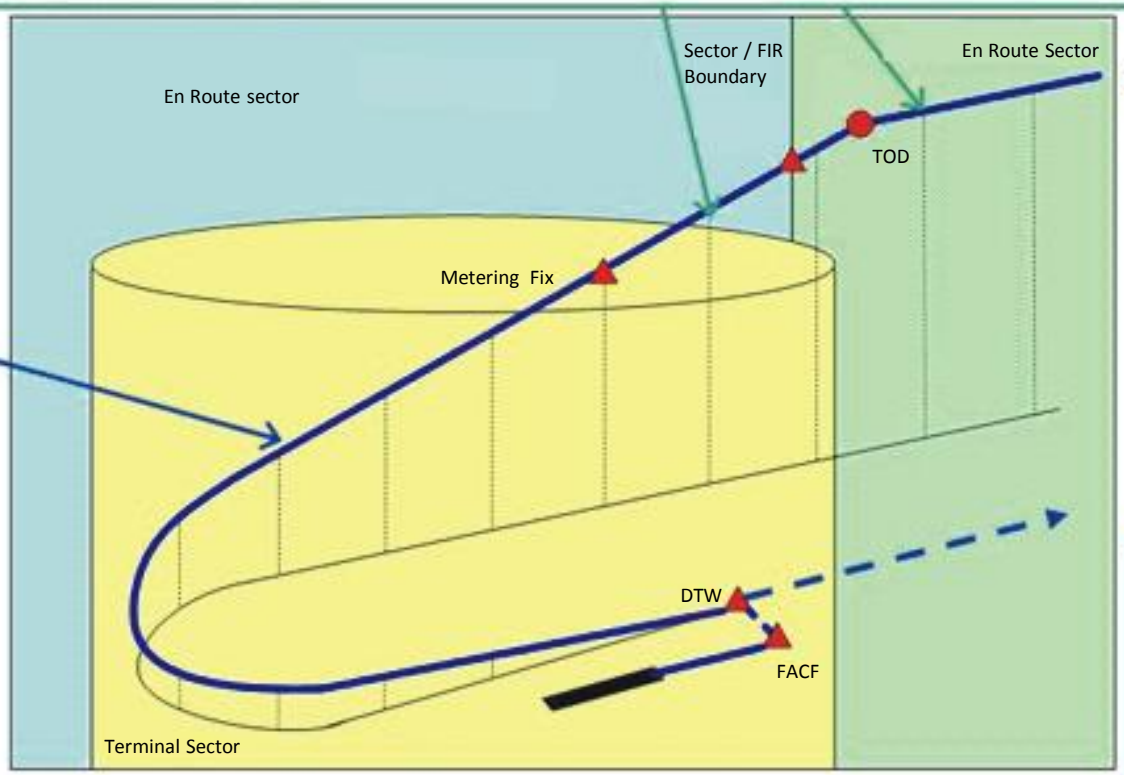
COMMUNICATION (COM) - NAVIGATION (NAV) - SURVEILLANCE (SUR)

Airspace Organization and Management (AOM) designers

ICAO SARPS

-Speed and route tailoring here better merges streams and enables extension of the arrival from downwind to the runway even during congested periods.

-Maximum use of aircraft avionics provides maximum flight efficiency for airlines and environment, and maximum predictability for ATS.



Standard operations:

Vectoring and level-off below metering fix

Standard operations:

Variable length downwind leg, with level-offs

Standard operations:

Variable length downwind leg, with level-offs

PBN - ATC Training

ATS procedures for airspace utilizing RNAV and RNP applications.

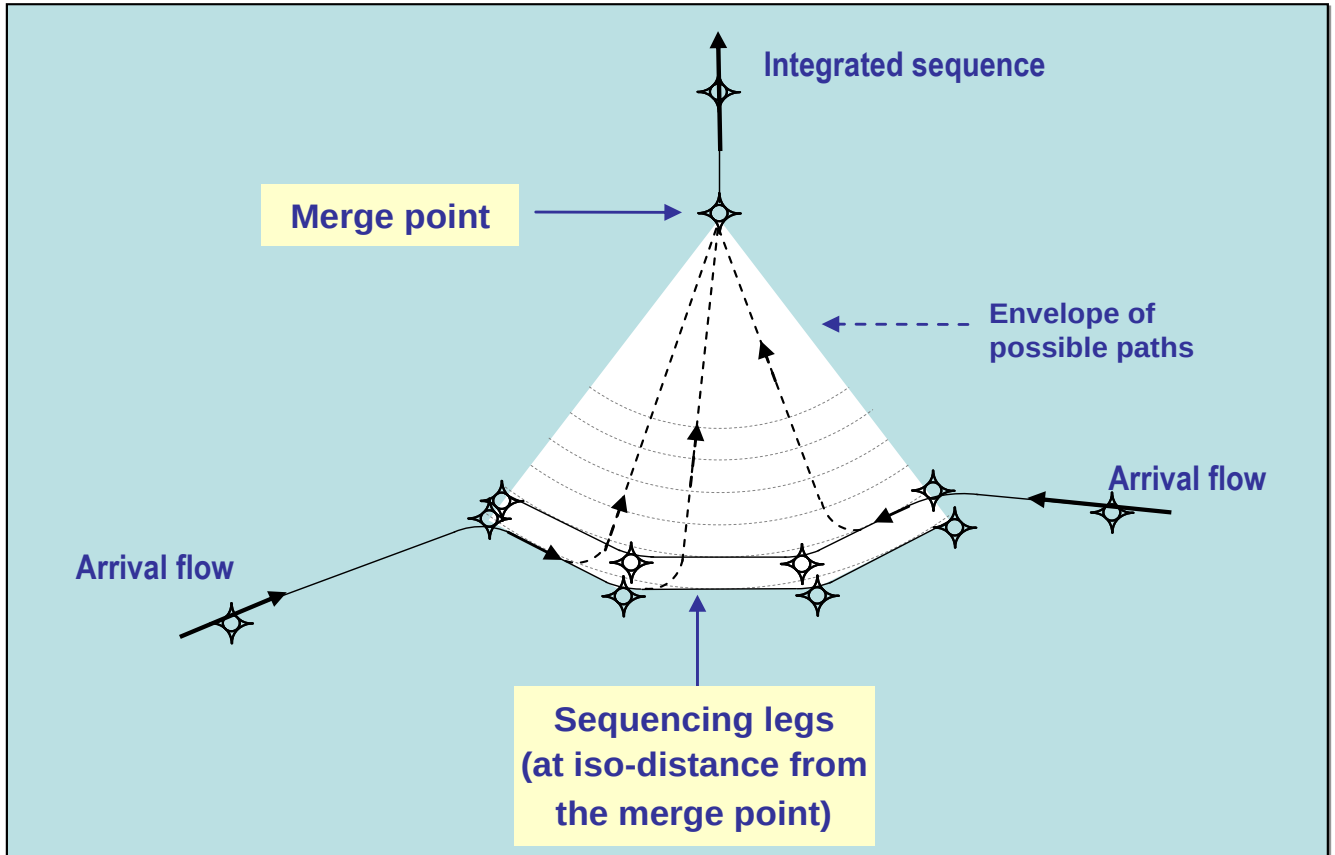
Include procedures to enable the use of the parallel offset on-board functionality or to enable the transition between airspaces having different performance and functionality requirements, as follows:

a) determining the specific points where the traffic will be directed as it transits from airspace requiring a navigation specification with less stringent performance and functional requirements to an airspace requiring a navigation specification having more stringent performance and functional requirements; and

b) coordinating efforts with relevant parties in order to obtain a regional agreement detailing the required responsibilities.

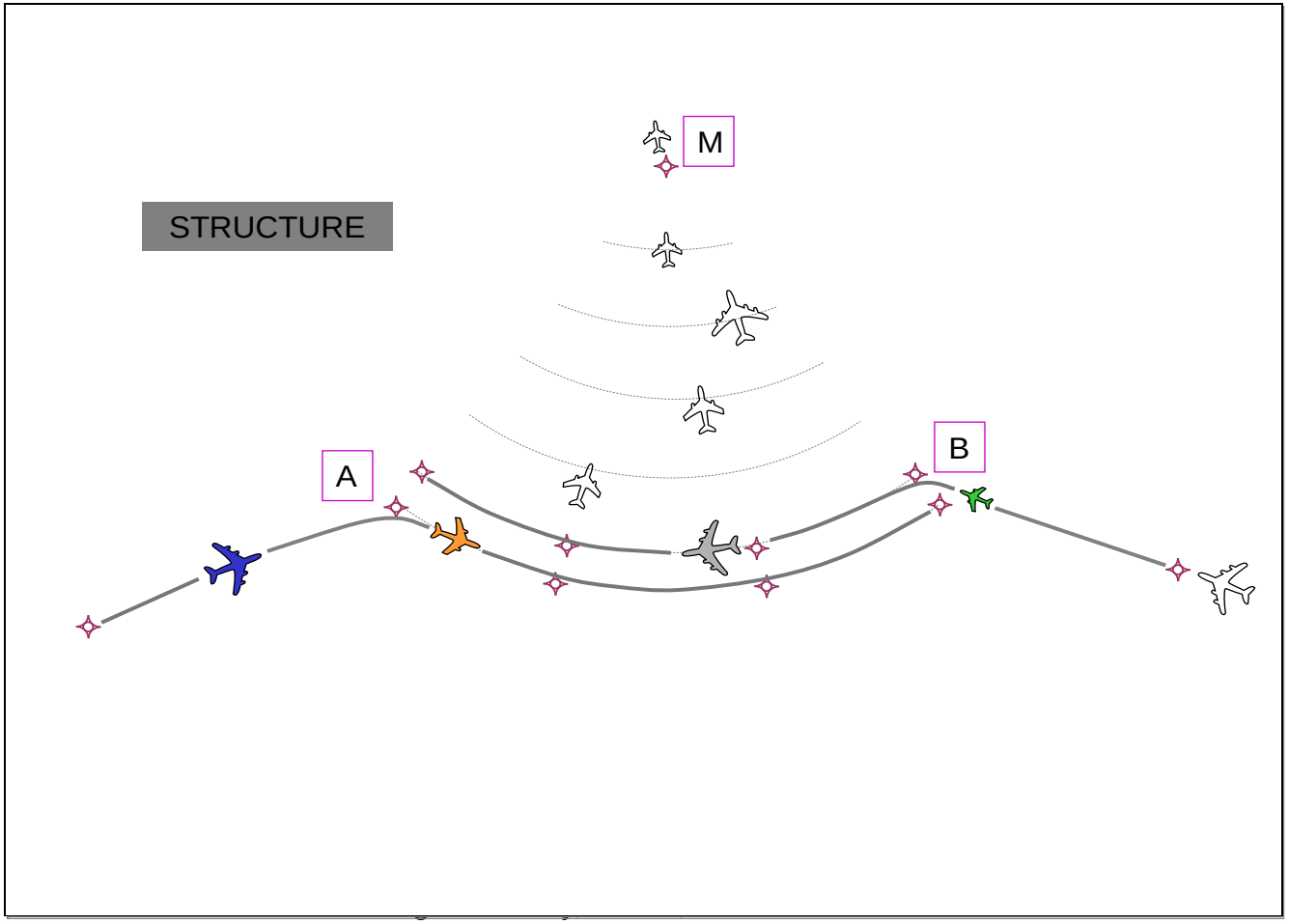
ATCOs should take appropriate action to provide increased separation and to coordinate with other ATC units as appropriate, when informed that the flight is unable to maintain the prescribed level of navigation performance.

Point Merge System (PMS)

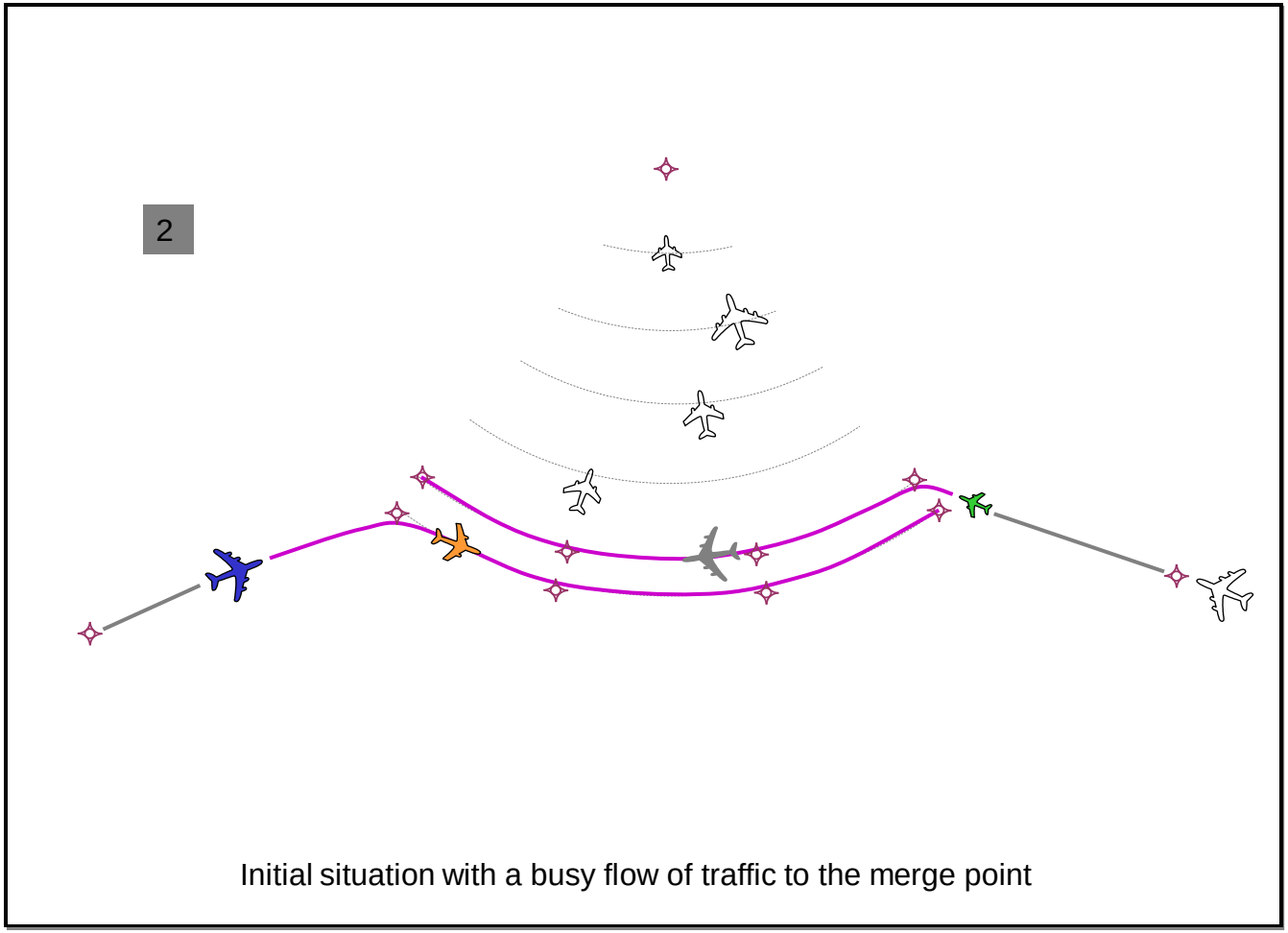


Point merge system - example with two inbound flows

Scenario (1/5)

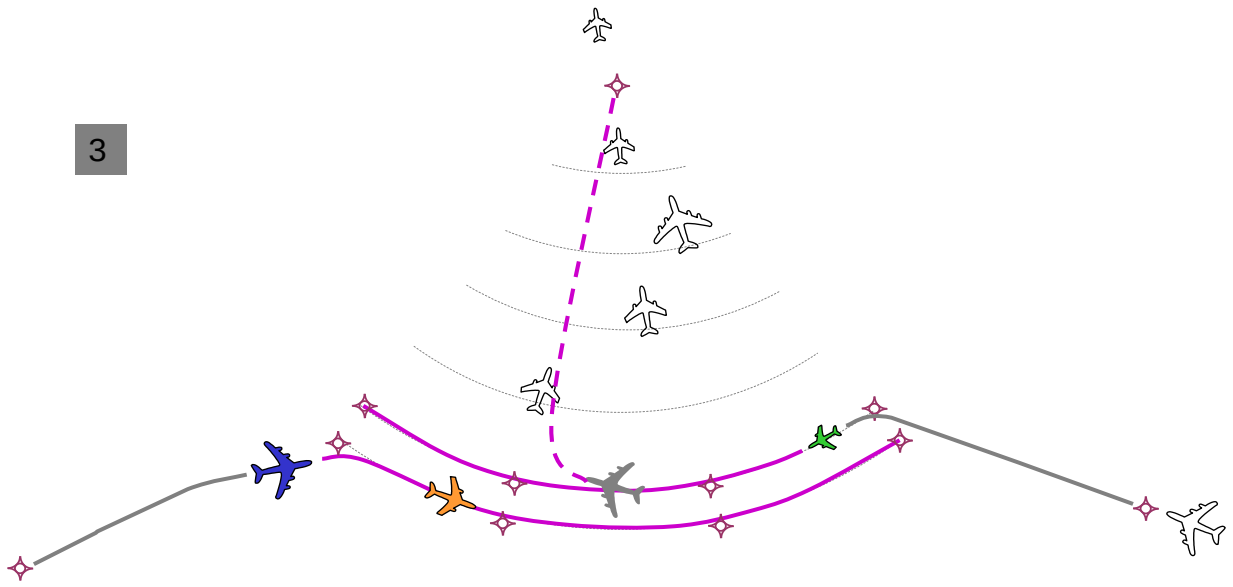


Scenario (2/5)



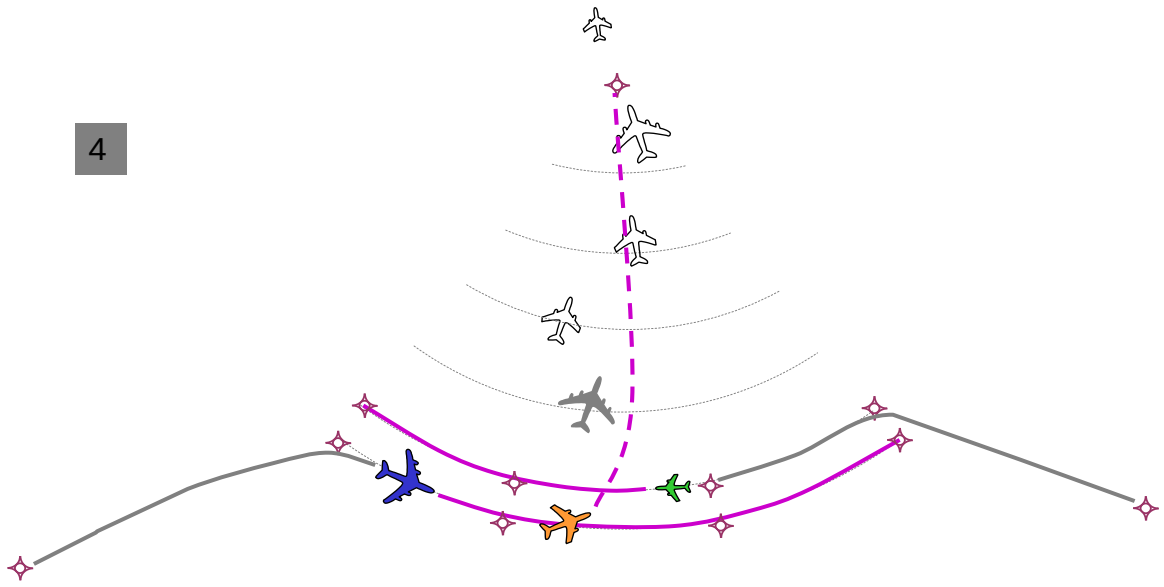
Initial situation with a busy flow of traffic to the merge point

Scenario (3/5)



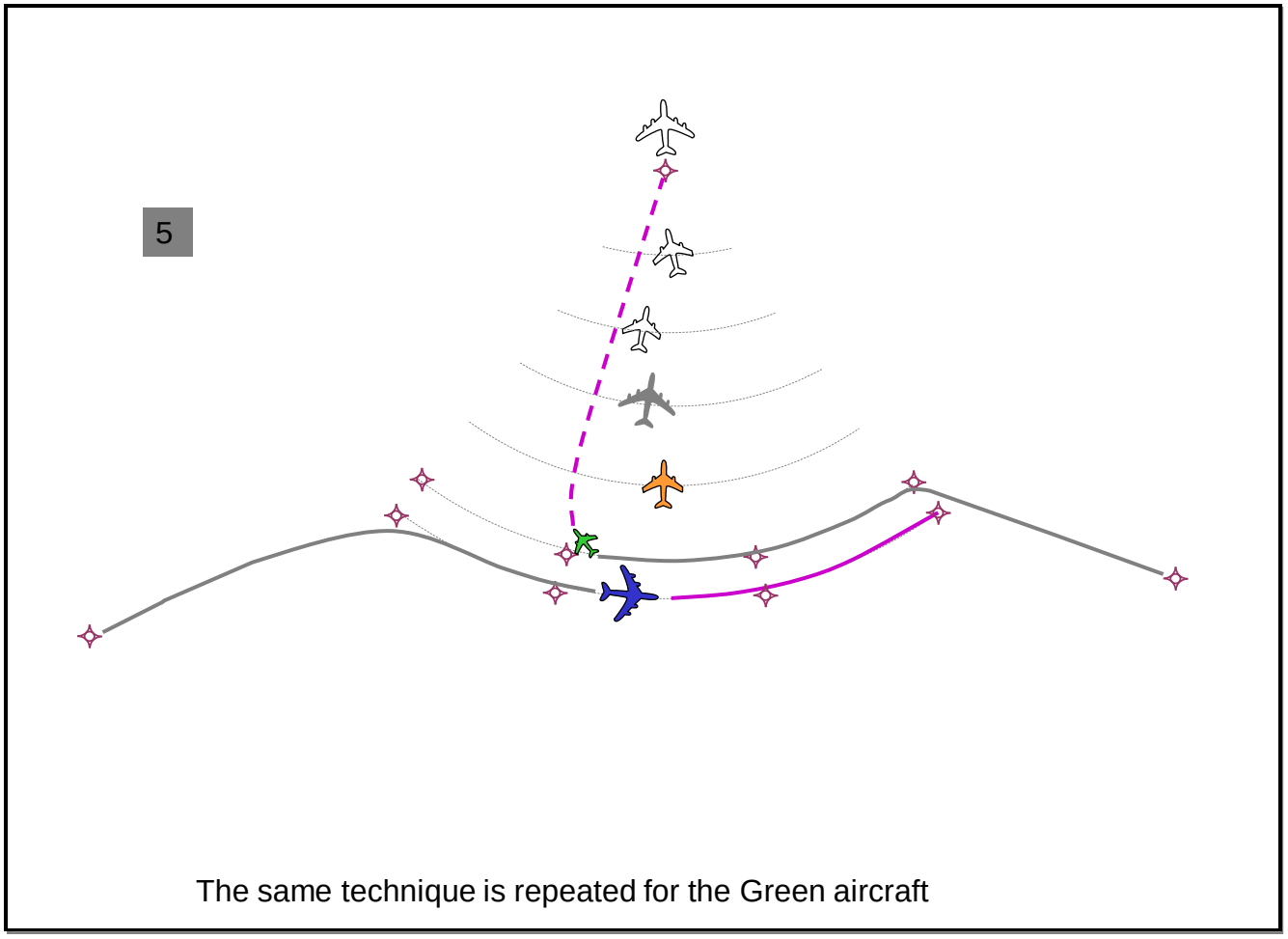
Grey heavy jet turns to the merge point.
Controller determines when to issue the “Direct to merge point” instruction to the Gold aircraft to ensure that the required WTC spacing behind the preceding aircraft will be achieved.

Scenario (4/5)



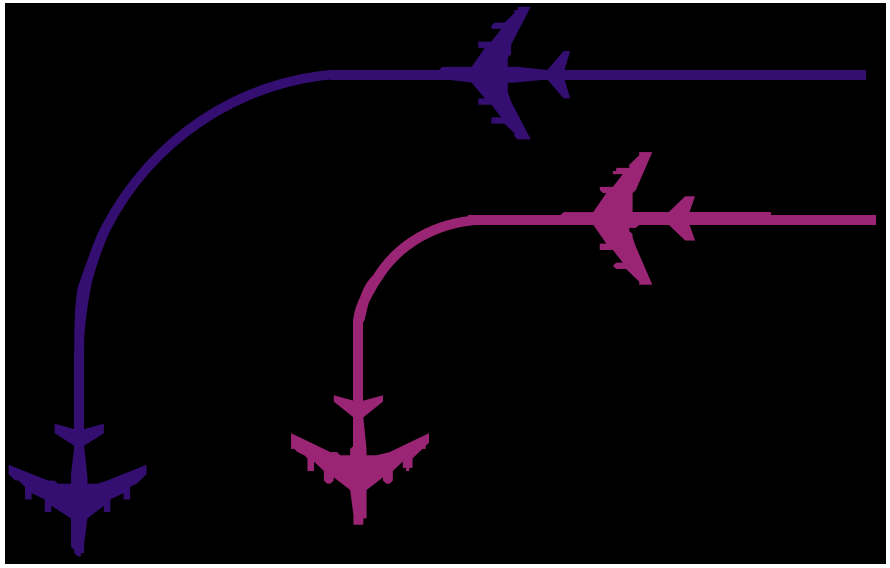
Controller issues the “Turn left direct to merge point” instruction to the Gold aircraft using the range ring arcs to assess the appropriate WTC spacing from the Grey aircraft.

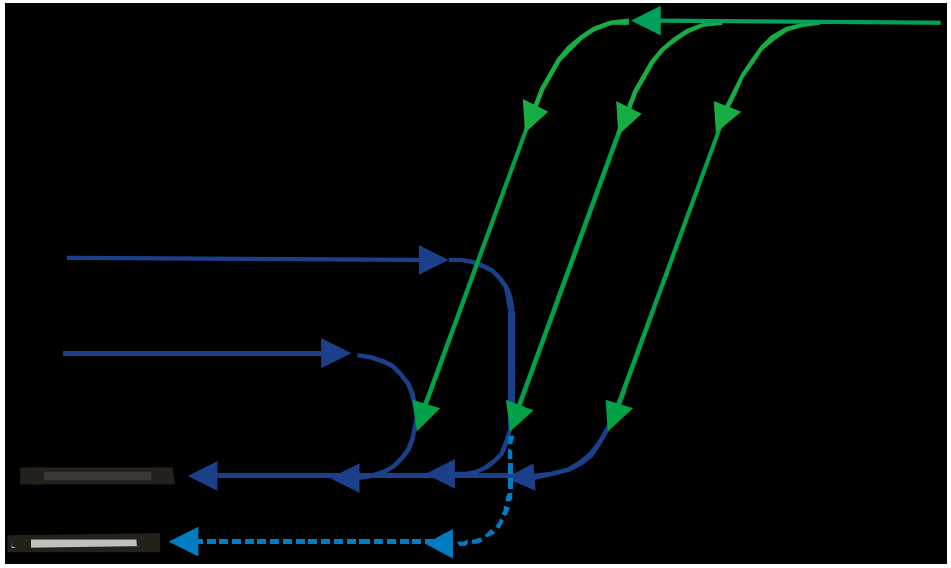
Scenario (5/5)



Operational Requirements

Reduce the distance required between laterally separated parallel ATS routes

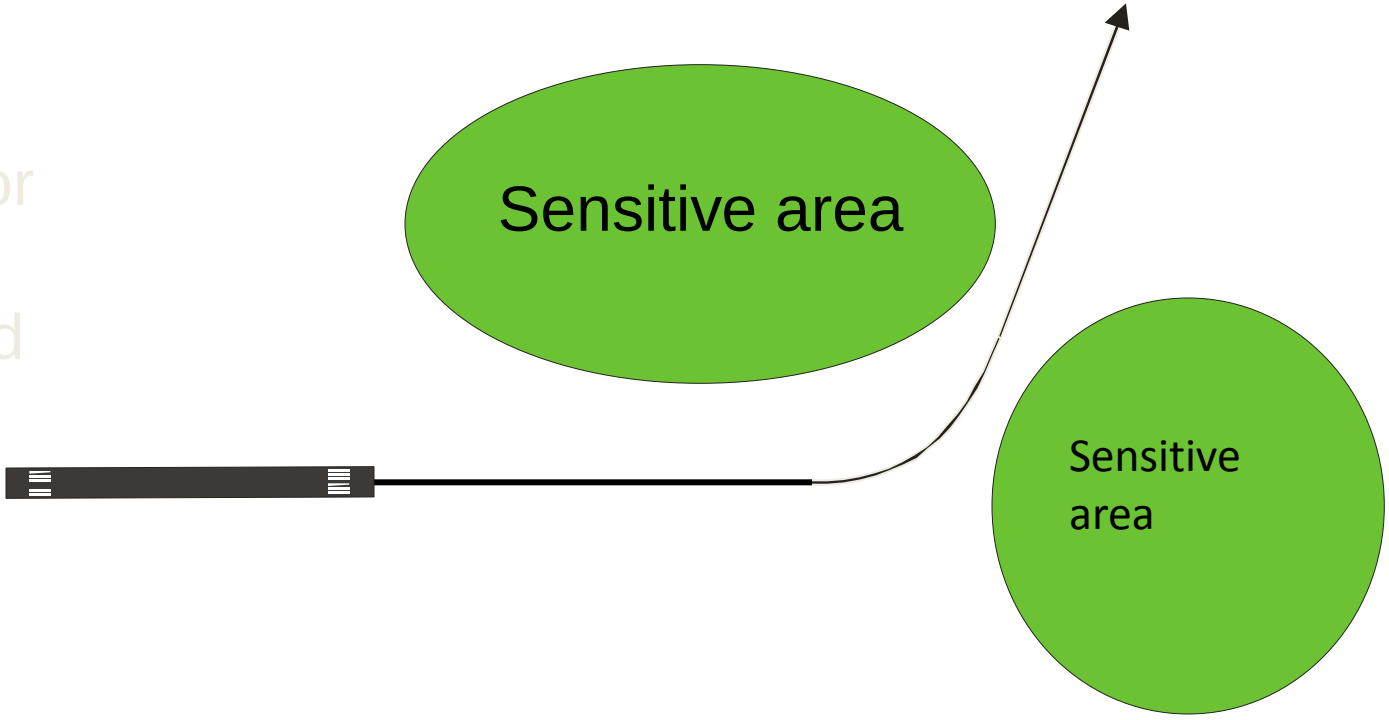




Operational Requirements (1)

Increase predictability of path flown

Enable routes where terrain or environmental impact demand increased accuracy

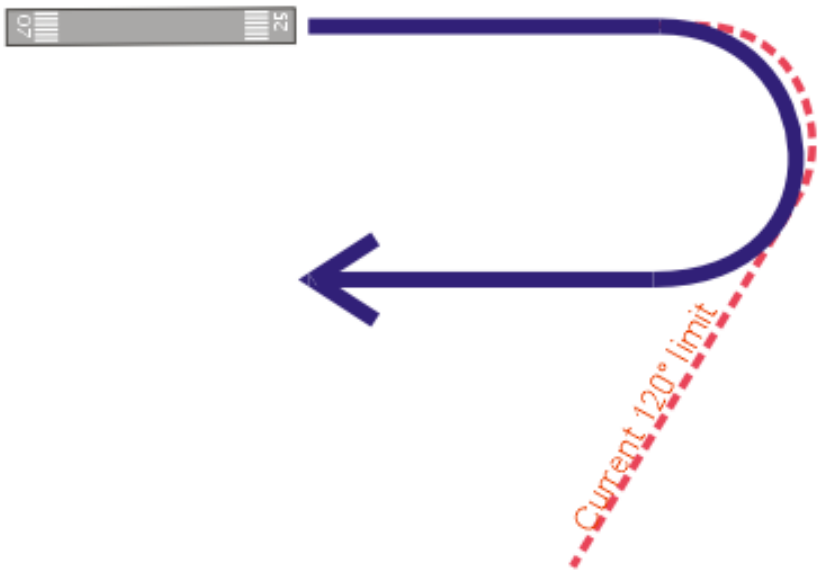


Operational Requirements (2)

Improved turn performance including containment of large angle changes

Benefits expected:

- Capacity:
  - Place routes where needed
  - Enable reduced route spacing
- Environmental:
  - Design routes more efficiently to meet environmental requirements



CDO Training

- a) speed restrictions
- b) level constraints or crossing restrictions
- c) the level of automation to be used
- d) the possible effect of wind, atmospheric pressure, altimeter setting and expected icing conditions
- e) the effect of the transition level
- f) ATC phraseology.

CDO Training and Awareness Material

a) CDO benefits and their local importance;

b) training requirements for the selected (open or closed) CDO facilitation method;

c) a simple pamphlet describing the aims and requirements for CDO;

d) the individual roles and responsibilities relevant to the conduct of individual CDO flights; and

e) method for providing ongoing feedback on progress to all participants.

PBN Enroute - ATC Training

RNAV 5:

a) How area navigation systems work :

i) include functional capabilities and limitations of this navigation specification;

ii) accuracy, integrity, availability and continuity; and

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

b) Flight plan requirements;

c) ATC procedures:

i) ATC contingency procedures;

ii) separation minima;

iii) mixed equipage environment (impact of manual VOR tuning);

iv) transition between different operating environments; and

v) phraseology.

PBN - ATC Training

RNAV 1 and RNAV 2

a) How area navigation systems work (in the context of this 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; and
- iv) waypoint fly-by versus fly-over concept (and differences in turn performance);

b) Flight plan requirements; and

c) ATC procedures:
- i) ATC contingency procedures;
- ii) separation minima;
- iii) mixed equipage environment (impact of manual VOR tuning);
- iv) transition between different operating environments; and
- v) phraseology.

RNP 4- ATC Training

a) How area navigation systems work:
i) functional capabilities and limitations of this navigation specification;
ii) accuracy, integrity, availability and continuity including on-board performance monitoring and alerting;
iii) GNSS receiver, RAIM, FDE, fault detection and integrity alerts; and
iv) waypoint fly-by versus fly-over concept (and different turn performance);

b) Flight plan requirements;

c) ATC procedures:

i) ATC contingency procedures;
ii) separation minima;
iii) mixed equipage environment (impact of manual VOR tuning);
iv) transition between different operating environments; and
v) phraseology.

Training specific: for application of 30/30 separation minima:

a) CPDLC communications;

b) ADS-C system and simulation training; and

c) effect of periodic reporting delay/failure on longitudinal separation.

RNP 2 - ATC Training

a) How area navigation systems work:

i) functional capabilities and limitations of this navigation specification;
ii) accuracy, integrity, availability and continuity including on-board performance monitoring and alerting;
iii) GNSS receiver, RAIM, FDE, fault detection and integrity alerts; and
iv) waypoint fly-by versus fly-over concept (and different turn performance);

b) Flight plan requirements;

c) ATC procedures:

i) ATC contingency procedures;
ii) separation minima;
iii) mixed equipage environment (impact of manual VOR tuning);
iv) transition between different operating environments; and
v) phraseology.

***Training specific* :**

a) RNP 2 ATS route control requirements (in either ATS surveillance or procedural control environments)

i) descend/climb clearances; and
ii) route reporting points;

b) RNP 2 related phraseology; and

c) impact of requesting an in-flight change to route.

RNP 1 - ATC Training

a) How area navigation systems work:

i) functional capabilities and limitations of this navigation specification;
ii) accuracy, integrity, availability and continuity including on-board performance monitoring and alerting;
iii) GNSS receiver, RAIM, FDE, fault detection and integrity alerts; and
iv) waypoint fly-by versus fly-over concept (and different turn performance);

b) Flight plan requirements;

c) ATC procedures:

i) ATC contingency procedures;
ii) separation minima;
iii) mixed equipage environment (impact of manual VOR tuning);
iv) transition between different operating environments; and
v) phraseology.

***Training specific* :**

a) RNP 1 STARs, SIDs, related control procedures:

i) radar vectoring techniques (where appropriate);
ii) open and closed STARs;
iii) altitude constraints; and
iv) descend/climb clearances;

b) RNP approach and related procedures;

c) RNP 1 related phraseology; and

d) impact of requesting a change to routing during a procedure

ADVANCED RNP (A-RNP) - ATC Training

a) How area navigation systems work:
i) functional capabilities and limitations of this navigation specification;
ii) accuracy, integrity, availability and continuity including on-board performance monitoring and alerting;
iii) Availability of ATS and infrastructure;
iv) GNSS receiver, RAIM, FDE, and integrity alerts; and
v) Leg transitions, relative turn performance of waypoint fly-by versus fly-over concept;

b) Flight plan requirements including the applicability of A-RNP to RNAV 1, RNAV 2, RNAV 5, RNP APCH, RNP 1, and RNP 2 navigation applications;

c) ATC procedures:

i) ATC contingency procedures;
ii) separation minima;
iii) mixed equipage environment (impact of manual VOR tuning);
iv) transition between different operating environments; and
v) phraseology
vi) ATC intervention considerations.

Training specific :
a) Related control procedures:
i) Vectoring techniques (where appropriate);
1) RF leg limitations including ground speed constraints;

b) RNP approach and related procedures;
i) Approach minima;
ii) Potential negative impact of issuing an amended clearance for a procedure when the aircraft is already established on the procedure due to possible difficulty in complying with revised procedure requirements. Sufficient time needs to be allowed for the crew to accomplish navigation systems reprogramming requirements, e.g. a change to the en-route or runway transition;

c) RNP en route:
i) FRT as a computed turn by the aircraft versus a unique en-route path segment;

d) Parallel offsets. RNP systems termination of offsets and return to original flight plan; and

RNP APCH - ATC Training

RNP APCH - Controller training:

a) How area navigation systems work:

i) functional capabilities and limitations of this navigation specification;

ii) accuracy, integrity, availability and continuity including on-board performance monitoring and alerting;

iii) GNSS receiver, RAIM, FDE, and integrity alerts; and

iv) waypoint fly-by versus fly-over concept (and different turn performances);

b) Flight plan requirements;

c) ATC procedures:

i) ATC contingency procedures;

ii) separation minima;

iii) mixed equipage environment (impact of manual VOR tuning);

iv) transition between different operating environments; and

v) phraseology.

***Training specific* :**

a) Related control procedures:

i) Radar vectoring techniques (where appropriate);

b) RNP approach and related procedures;

i) including T and Y approaches; and

ii) approach minima;

c) impact of requesting a change to routing during a procedure.

RNP APCH - ATC Training

a) How area navigation systems work:

i) functional capabilities and limitations of this navigation specification;
ii) accuracy, integrity, availability and continuity including on-board performance monitoring and alerting;
iii) GNSS receiver, RAIM, FDE, and integrity alerts; and
iv) waypoint fly-by versus fly-over concept (and different turn performances);

b) Flight plan requirements;

c) ATC procedures:

i) ATC contingency procedures;
ii) separation minima;
iii) mixed equipage environment (impact of manual VOR tuning);
iv) transition between different operating environments; and
v) phraseology.

***Training specific* :**

a) Related control procedures:

i) Radar vectoring techniques (where appropriate);

b) RNP approach and related procedures;

i) including T and Y approaches; and
ii) approach minima;

c) impact of requesting a change to routing during a procedure.

RNP AR APCH - ATC Training

a) How area navigation systems work:

i) functional capabilities and limitations of this navigation specification;
ii) accuracy, integrity, availability and continuity including on-board performance monitoring and alerting;
iii) GNSS receiver, RAIM, FDE, and integrity alerts;
iv) waypoint fly-by versus fly-over concept (and different turn performances); and
v) RF leg applications in RNP AR APCH procedure design;

b) Flight plan requirements;

c) ATC procedures:

i) ATC contingency procedures;
ii) separation minima;
iii) mixed equipage environment (impact of manual VOR tuning);
iv) transition between different operating environments; and
v) phraseology.

***Training specific* :**

a) Related control procedures:

i) Radar vectoring techniques (where appropriate);
— RF leg limitations;
— airspeed constraints;

b) RNP AR APCH procedures;

i) approach minima; and
ii) additional requests for altimeter settings;

c) impact of requesting a change to routing during a procedure.

PBN, Navigation Specification

NAVEGATION SPECIFICATION	FLIGHT PHASE							
	En-route Oceanic/ Remote	En-Route Continental	Arrival	Approach				DEP
				Initial	Interm.	Final	Miss	
RNAV 10	10							
RNAV 5		5						
RNAV 2		2						2
RNAV 1		1		1	1		1	1
RNP 4	4							
RNP 2	2	2						
RNP 1				1[a]	1[a]		1[ab]	1[a,c]
Advanced RNP	2	2 or 1	1	1	1	0.3	1	1
RNP APCH				1	1	0.3	1	
RNP AR APCH				1-0.1	1-0.1	0.3-0.1	1-0.1	
RNP 0.3		0.3	0.3	0.3	0.3		0.3	0.3

ICAO New FPL 2012 & PBN

PBN/ indication of RNAV and/or RNP capabilities. Include as many of descriptors below, as apply to the flight, up to a maximum of 8 entries, i.e. a total of not more than 16 characters.

In Item **10**: R = PBN levels that can be met are shown in Item 18 if FPL

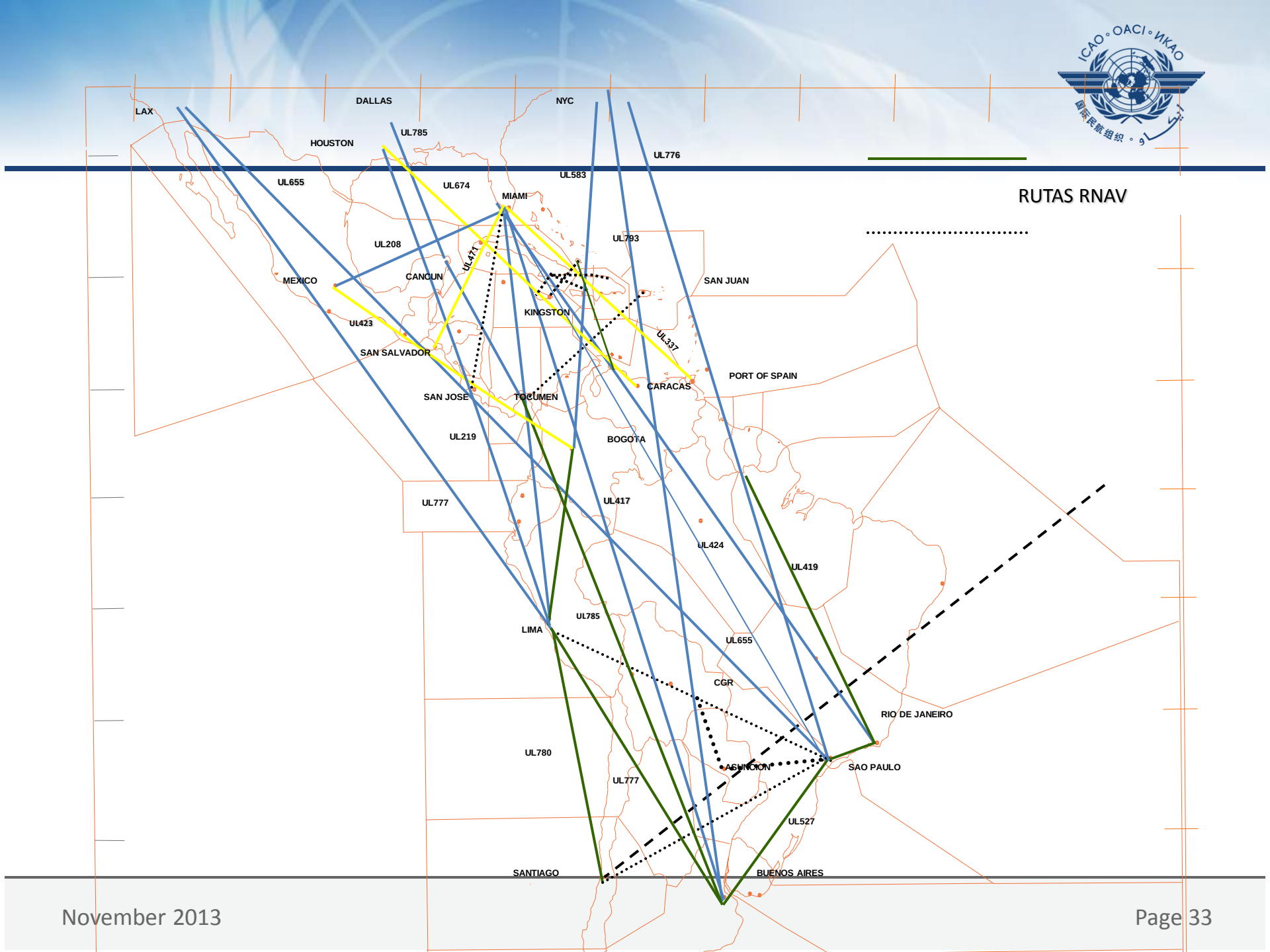
In Item **18**:

RNAV specifications

AI	RNA 10 (RNP 10)
B1	RNAV 5 all permitted sensors
B2	RNAV 5 GNSS
B3	RNAV 5 DME/DME
B4	RNAV 5 VOR/DME
B5	RNAV 5 INS or IRS
B6	RNAV 5 LORANC
C1	RNAV 2 all permitted sensors
C2	RNAV 2 GNSS
C3	RNAV 2 DME/DME
C4	RNAV 2 DME/DME/IRU
D1	RNAV 2 all permitted sensors
D2	RNAV 1 GNSS
D3	RNAV 1 DME/DME
D4	RNAV 1 DME/DME/IRU

RNP specifications

L1	RNP4
O1	Basic RNP 1 all permitted sensors
O2	Basic RNP 1 GNSS
O3	Basic RNP 1 DME/DME
O4	Basic RNP 1 DME/DME/IRU
S1	RNP APCH
S2	RNP APCH with BARO-VNAV
T1	RNP AR APCH with RF (special authorization required)
T2	RNP AR APCH without RF (special authorization required)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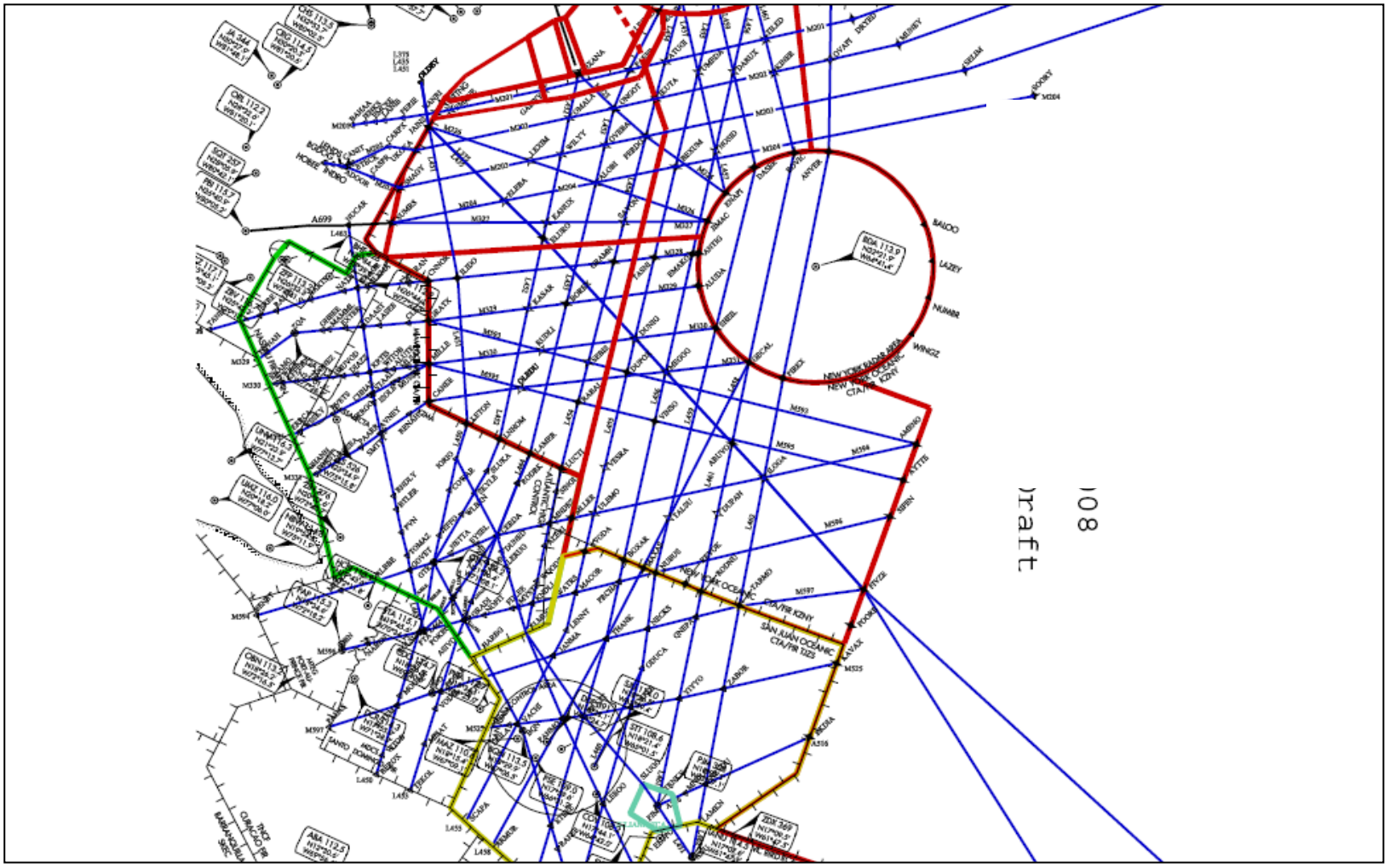
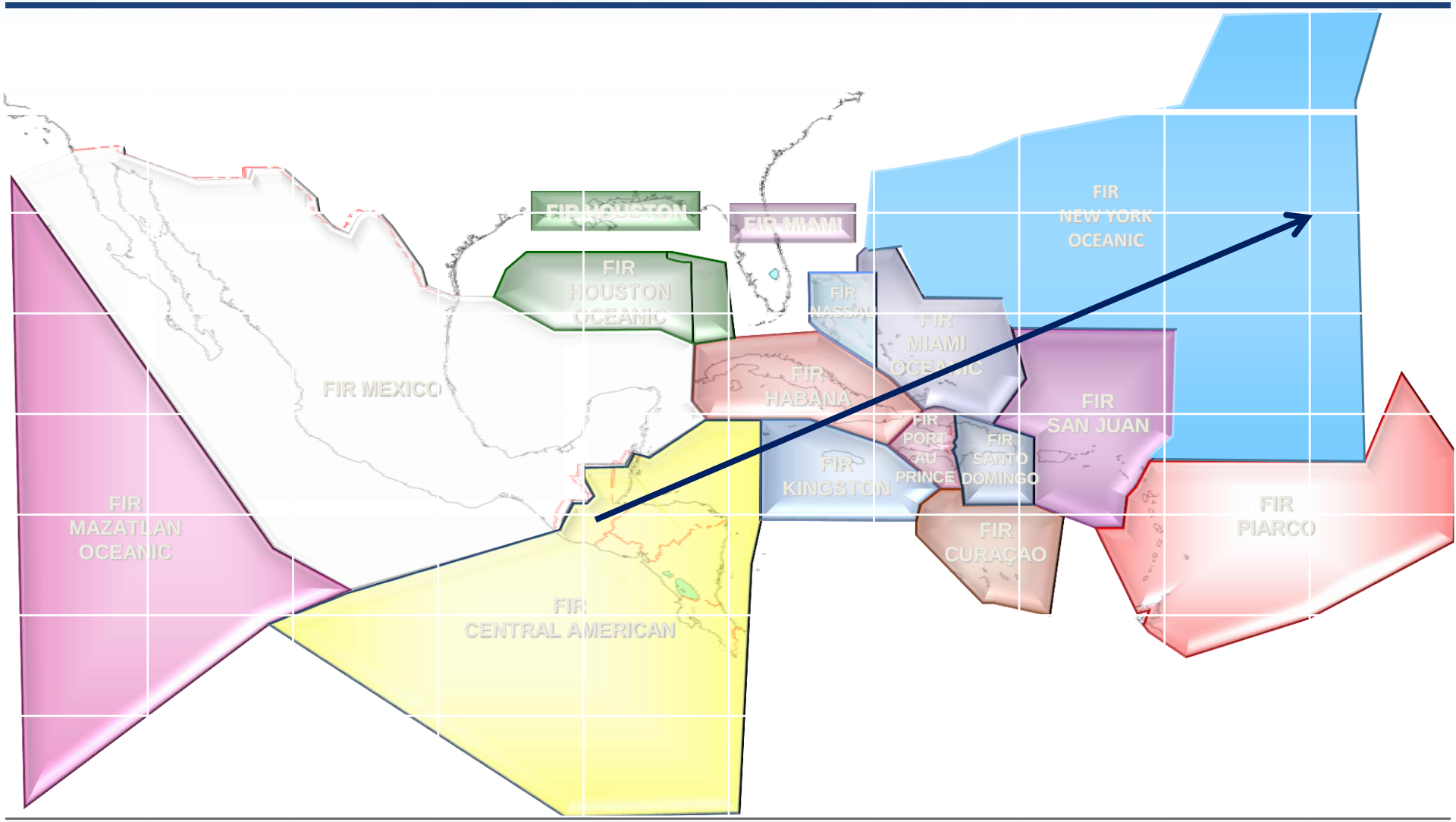
LAX
DALLAS
NYC
HOUSTON
UL785
UL776
UL655
UL674
UL583
MIAMI
UL793
UL208
UL471
MEXICO
CANCUN
SAN JUAN
KINGSTON
UL423
UL337
SAN SALVADOR
PORT OF SPAIN
CARACAS
SAN JOSE
TOCUMEN
UL219
BOGOTA
UL777
UL417
UL424
UL419
UL785
LIMA
UL655
CGR
RIO DE JANEIRO
UL780
ASUNCION
SAO PAULO
UL777
UL527
SANTIAGO
BUENOS AIRES

WATRS STRUCTURE




FIR HOUSTON
FIR MIAMI
FIR NEW YORK OCEANIC
FIR HOUSTON OCEANIC
FIR NASSAU
FIR MIAMI OCEANIC
FIR MEXICO
FIR HABANA
FIR SAN JUAN
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European and North Atlantic (EUR/NAT) Office Paris
Middle East (MID) Office Cairo
Eastern and Southern African (ESAF) Office Nairobi
Asia and Pacific (APAC) Office Bangkok

Thank You