



INTERNATIONAL CIVIL AVIATION ORGANIZATION

A United Nations Specialized Agency

PBN Airspace Design Workshop

AIRSPACE CONCEPT DEVELOPMENT AND IMPLEMENTATION

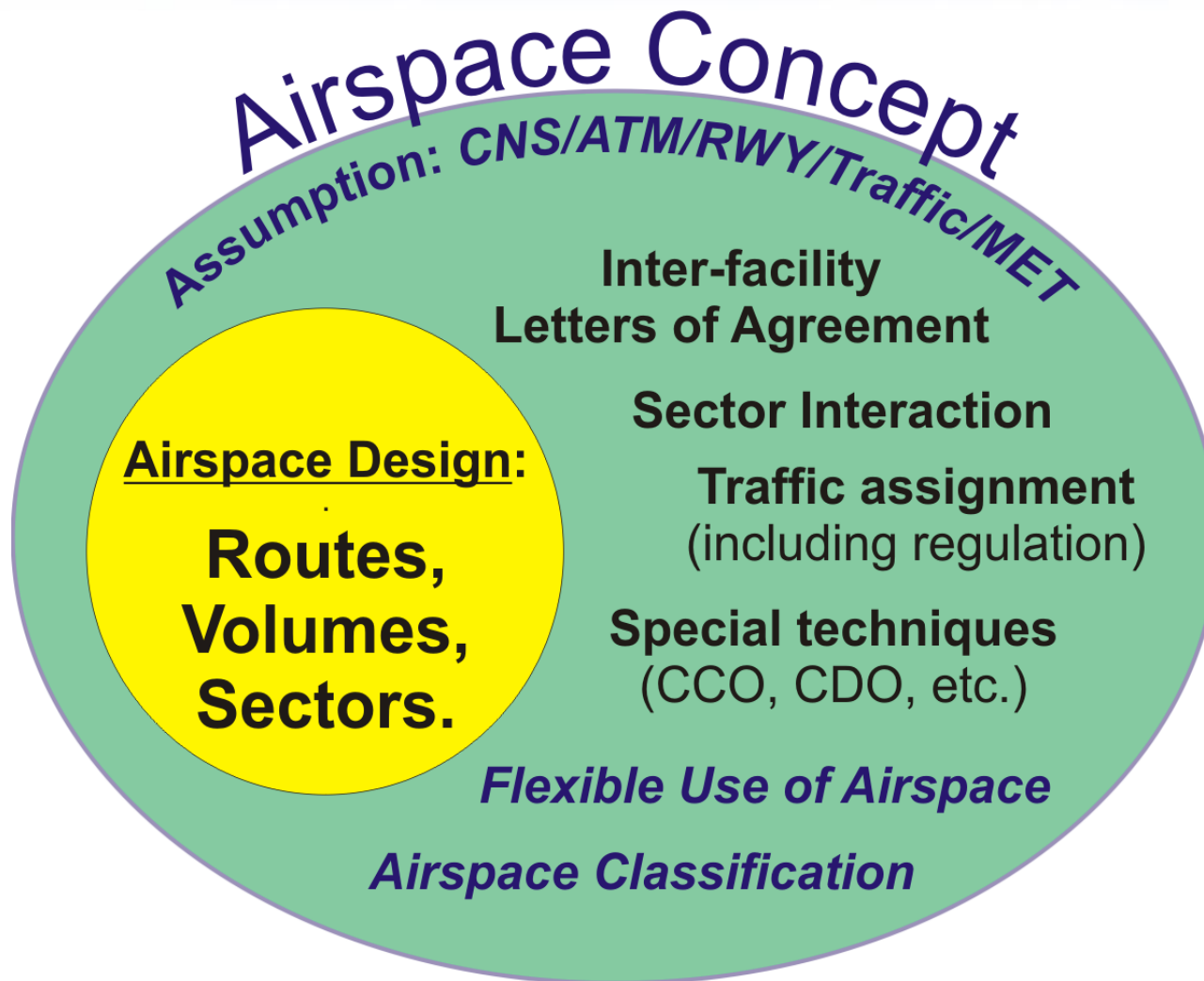
**Asia and Pacific Regional Sub-Office
Beijing, China**

Learning Objectives



- **Overview of PBN Airspace Concept Development and Implementation Process**
- **Review of activities involved in Planning, Designing, Validation and Implementation**

Airspace Concept



Airspace Concept

Assumption: CNS/ATM/RWY/Traffic/MET

Inter-facility
Letters of Agreement

Sector Interaction

Traffic assignment
(including regulation)

Special techniques
(CCO, CDO, etc.)

Flexible Use of Airspace

Airspace Classification

Airspace Design:

**Routes,
Volumes,
Sectors.**

Implementation Process



4 Distinct Phases

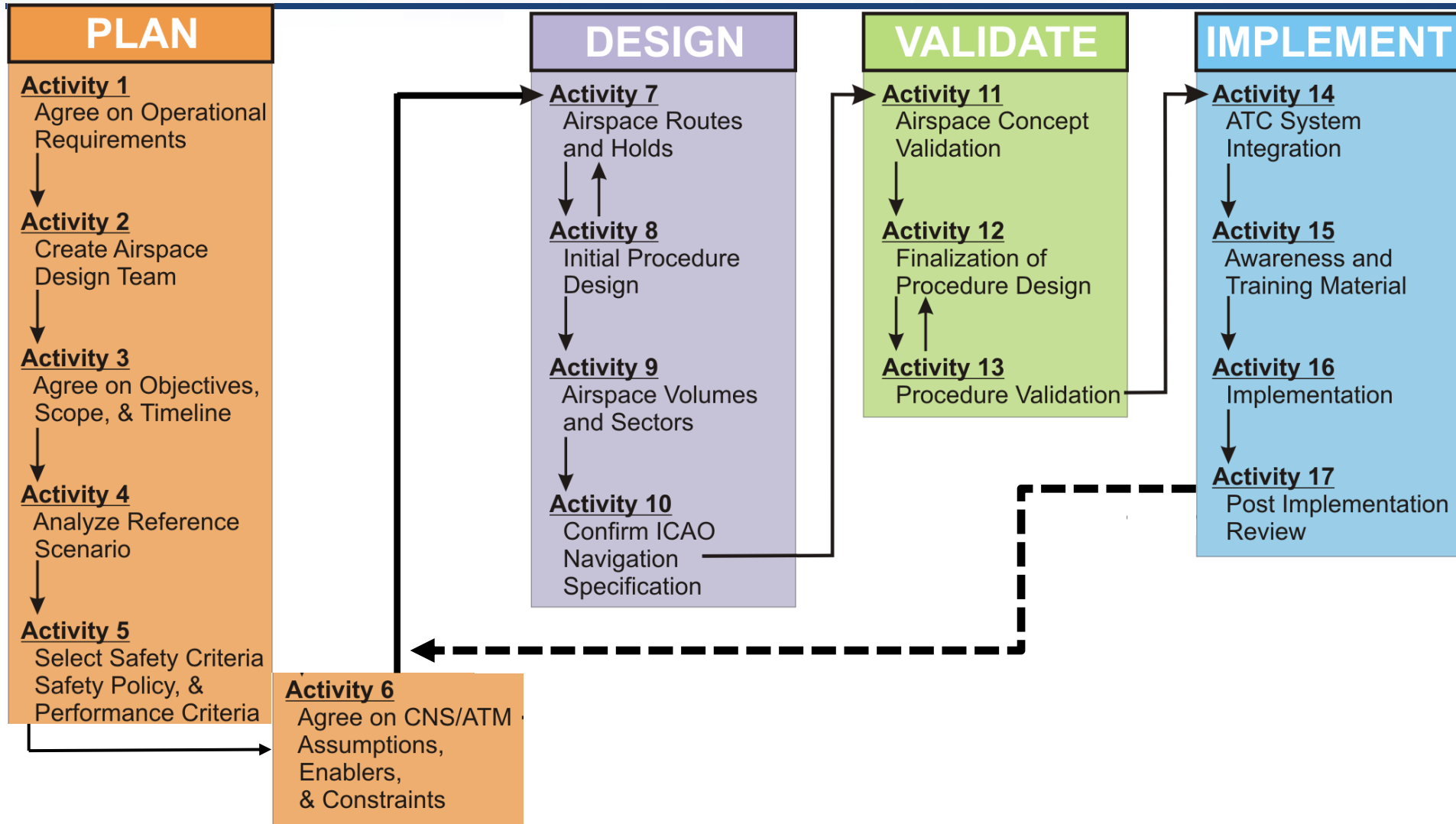
PLAN

DESIGN

VALIDATE

IMPLEMENT

Implementation Activity Overview



Activity 1

PLAN



Agree on Operational Requirements

- Safety
- Capacity
- Efficiency
- Environment
- Accessibility
- New Developments

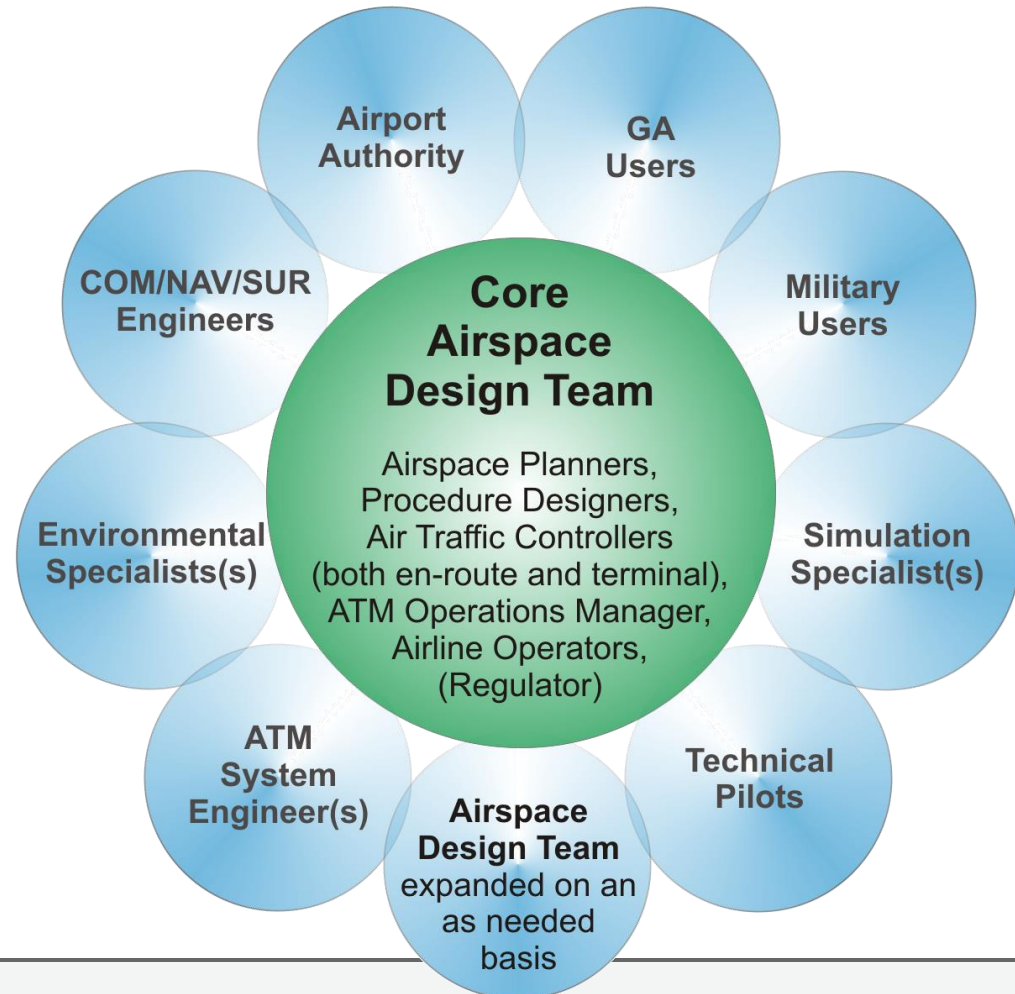
Activity 2



PLAN

Create Airspace Design Team

- Led by ATM/airspace specialist
- ATC (Approach and Area controllers)
- ATM & CNS specialist
- Procedure designers
- Technical pilots
-



Activity 3

PLAN



Project objectives, scope and timescales

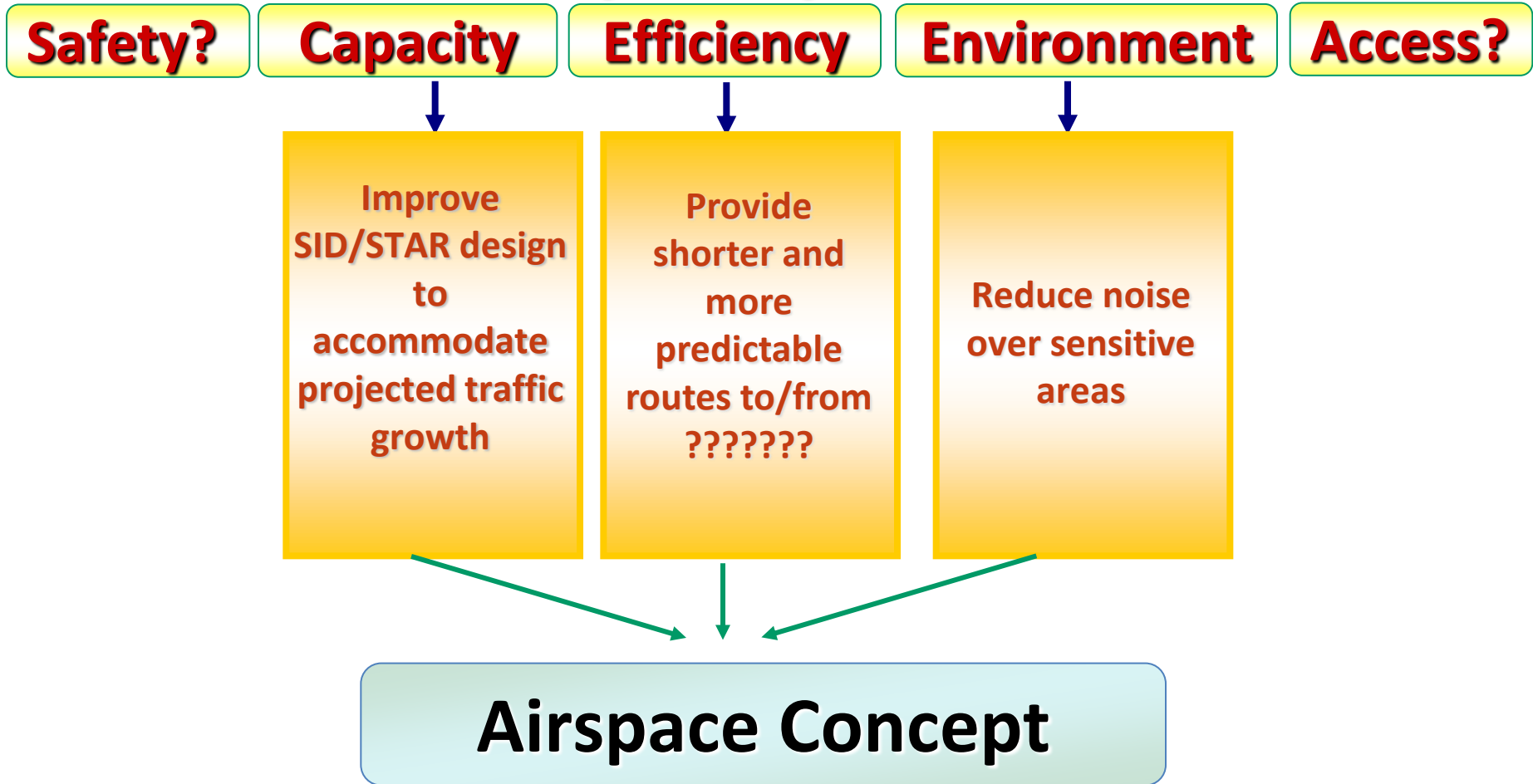
- **Objective derived from Ops requirements**
- **Scope !! (sets the limit of the project)**
 - **Time**
 - **Resources**
- **Timescales**

Activity 3



PLAN

Project objectives



Activity 3



PLAN

Project objectives - Additional Considerations

Example:

Although GNSS is associated primarily with navigation, GNSS is also the backbone of ADS-B surveillance applications.

As such, GNSS positioning and track-keeping functions are no longer “confined” to being a navigation enabler to an airspace concept. GNSS, in this case, is also an ATS surveillance enabler.

The same is true of data-link communications: data are used by an ATS surveillance system (for example, in ADS-B and navigation).

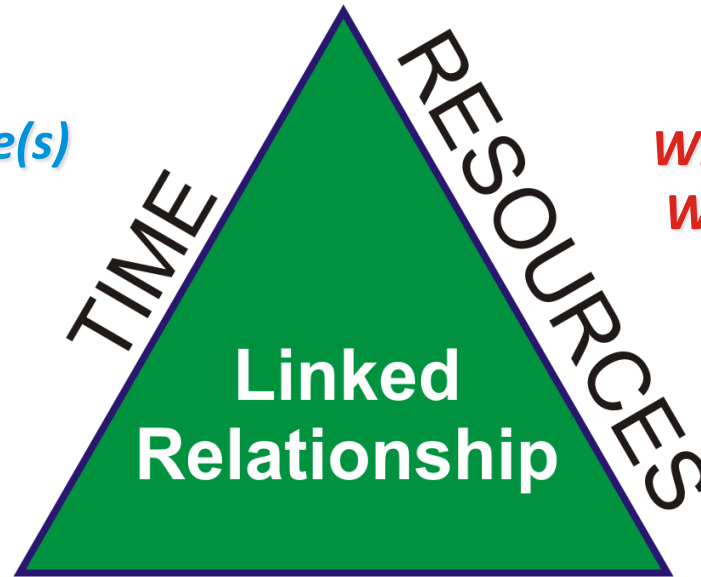
Activity 3



PLAN

Project objectives, scope and timescales

*Implementation Date(s)
Phases of Work?*



*Which Human Resources?
What about the budget?*

SCOPE

*What is the Objective ?
How much can be done?
What cannot be done?*

Beware of Project Creep!

Activity 3



PLAN

Planning Example - PROJECT PLAN

		<u>ACTIVITY</u>	<u>Timeline Number of WorkDays</u>	<u>Parallel Days</u>	<u>Total Work Days</u>	<u>Start Date</u>	<u>Completion Date</u>
PLAN	1	Agree on Operational Requirements	10	0	10	9-Feb-2013	22-Feb-2013
	2	Create Airspace Design Team	5	0	5	22-Feb-2013	1-Mar-2013
	3	Agree on Objectives, Scope & Timeline	15	0	15	1-Mar-2013	22-Mar-2013
	4	Analyze Reference Scenario	15	0	15	22-Mar-2013	12-Apr-2013
	5	Select Safety Criteria, Safety Policy, & Performance Criteria	10	0	10	12-Apr-2013	26-Apr-2013
	6	Agree on CBS/ATM Assumptions	12	0	12	26-Apr-2013	14-May-2013
DESIGN	7	Design Airspace Routes and Holds	14	0	14	14-May-2013	3-Jun-2013
	8	Initial Procedure Design	20	0	20	3-Jun-2013	1-Jul-2013
	9	Design Airspace Volumes and Sectors	20	0	20	1-Jul-2013	29-Jul-2013
	10	Confirm ICAO Navigation Specification	5	0	5	29-Jul-2013	5-Aug-2013
VALIDATE	11	Airspace Concept Validation	20	0	20	5-Aug-2013	2-Sep-2013
	12	Finalize Procedure Design	22	0	22	2-Sep-2013	2-Oct-2013
	13	Procedure Validation	20	0	20	2-Oct-2013	30-Oct-2013
IMPLEMENT	14	ATC System Integration	20	10	30	16-Oct-2013	27-Nov-2013
	15	Awareness and Training Material	0	30	30	16-Oct-2013	27-Nov-2013
	16	Implementation	1	0	1	27-Nov-2013	28-Nov-2013
	17	Post Implementation Review	30	0	30	28-Nov-2013	9-Jan-2014
					279	total	END DATE
		TIMELINE DAYS REQUIRED	239			workdays	9-Jan-2014
	*note: Uses WORKDAY function to exclude weekend and holiday days						

Activity 4

PLAN



Analysis of the reference scenario

Why?

- ❖ **Reference Scenario enables you to identify your current operations**
 - **Positive**
 - **Negative**
 - **Benchmark**

Activity 4

PLAN



Analysis of the reference scenario

Why Not?

- ❖ In order to improve you need to measure
 - No means of comparison
 - New concept could be worse
 - Using only procedures and LOAs will not provide realistic overview

Activity 4

PLAN



Obtaining Information

- **Predominant Runway-in-use at airport(s) within existing Terminal airspace.**
- **Statistical analysis of existing data over the last few years**
- **Current Traffic Demand and its geographic and time distribution.**
- **Traffic samples can be obtained from the local ATC Unit**
- **Analysis of the Traffic sample e.g. IFR/VFR mix; Fleet Mix; Aircraft performance mix, etc**
- **Traffic sample. Obtained as above.**

Activity 4

PLAN



Obtaining Information

- Routes (IFR & VFR), instrument approach procedures and Holding patterns/areas.
- **AIP and traffic sample;**
- Radar vectoring patterns
- **Operational controllers**
- Airspace dimensions
- **AIP and Operational controllers**

Activity 4

PLAN



Analysis of the reference scenario

Reference Scenario

Routes, Airspace, Volume, Sectorisation

Assumptions, Enablers, Constraints

New Scenario

Routes, Airspace, Volume, Sectorisation

Assumptions, Enablers, Constraints

Compare

Compare

System Performance

System Performance

Activity 4



PLAN

Critical Review

- Identify operational problem areas
- Identify constraints
- Identify mitigation and enablers

Refining Design Objectives

- Current flaws or weaknesses used to improve design objectives

Activity 4

PLAN



Quality Management

- ❖ **To measure is to know**
- ❖ **Constant process**
- ❖ **When correctly applied**
 - **Little effort**
 - **Easy/early adaptation to changes**
 - **Customer orientated**
 - **Reduces Iterations / Corrections**

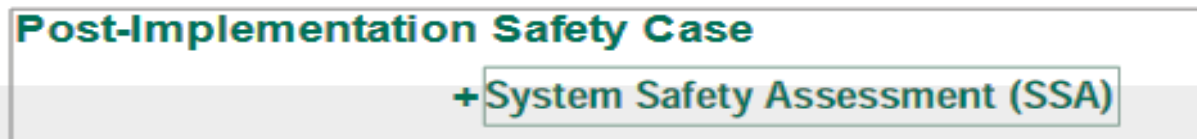
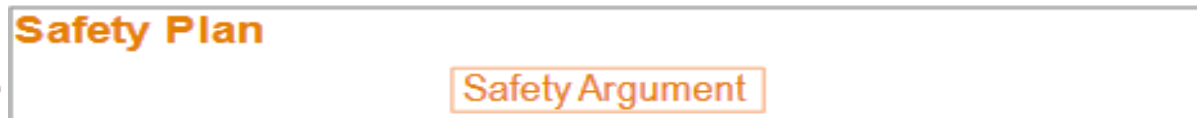
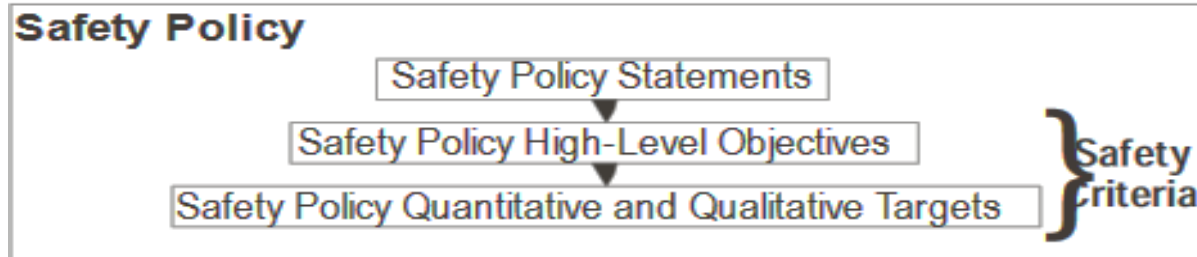
Activity 5

PLAN



Safety & Performance Criteria

Pre-Implementation



Activity 5

PLAN



Select Safety Criteria, Safety Policy and Performance Criteria

- Select Safety Management system
- Select Safety Assessment Methodology
- What evidence is needed to prove safety of design
- Set success criteria

Activity 5

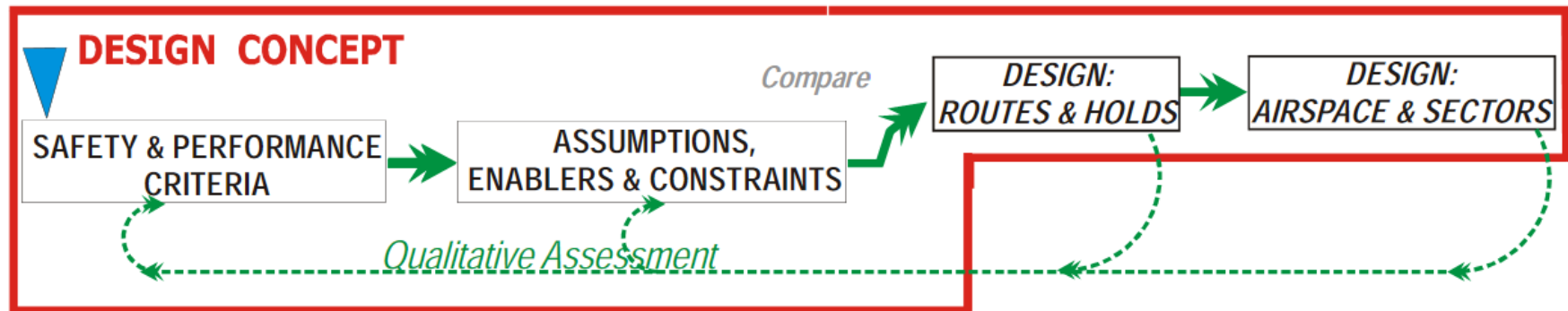
PLAN



Why have safety and performance criteria?

- Measure performance
- Measure safety
- Determine success of implementation

Interconnections



Activity 5

PLAN



Assessment

❖ Qualitative Assessment

- Expert judgement used to assess the design based on ICAO SARPs and Procedures

❖ Quantitative Assessment

- Quantified results produced in the form of numerical data e.g. capacity increased by 20%

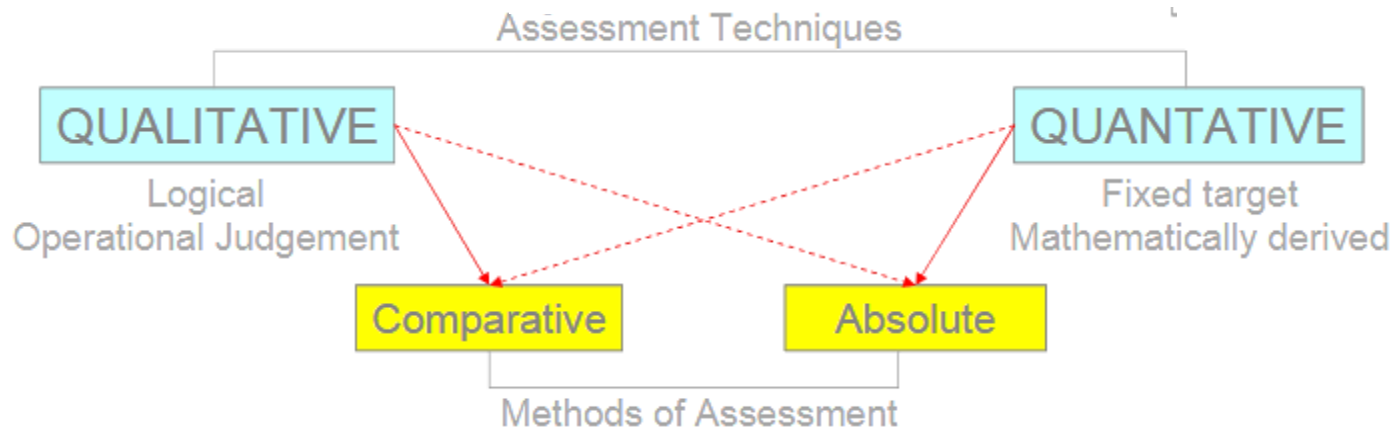
Both Qualitative and Quantitative assessment are crucial to safety and performance assessment

Activity 5

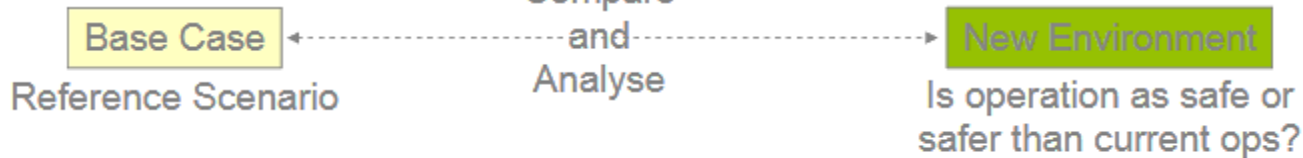


PLAN

Evaluating Safety



Comparative:



Absolute:



Activity 5

PLAN



Evaluating Safety

❖ Comparative Assessment

➤ Reference system must sufficiently resemble the new system to be introduced (typically the case with airspace changes)

➤ **Comparative** *does not* automatically mean 'qualitative': Comparisons can be made between two TLS.

❖ Absolute method often used for route spacing or determination of separation minima (ICAO)

❖ Professional judgement/common sense is a good synonym for 'Qualitative'

Activity 6

PLAN



Agree on ATM/CNS assumptions (Current & Future)

Traffic Analysis

Representative Traffic Sample
Distribution - Time/Geography
Cross check adjacent facility traffic
IFR/VFR mix
Civil/Military mix
Acft performance mix
(jet/prop/helo)

Navigation

ACFT Navigation Equipage
NAV Infrastructure and Coverage
PBN Conventional Mix

Runway in use (primary/secondary)

Available runways/length
Meteorological assumptions
Landing Aids
Greenfield Site? Orientation choice?
Runway usage statistics

ATC System

Sectors/Personnel/Equipment
Traffic Sequencing and Management

Surveillance Means/Coverage

Communications Means/Coverage

Activity 6

PLAN



Fleet Assumptions

- ❖ **What's in my fleet?**
 - **Jets**
 - **Turbo props**
 - **Piston**
- ❖ **What level of navigation qualification?**
 - **What certification?**
- ❖ **Upgrading a fleet costs**
 - **Retrofits must be *worth* the cost. > CBA**

Activity 6

PLAN



Assumptions / Enablers & Constraints

CONSTRAINTS	MITIGATION	ENABLERS
High Terrain on final approach RWY X	Increase ILS angle by 1°?	Specification change for ILS
Multiple airports within close proximity with poor co-ordination agreement	Letter of Agreement	EUROCONTROL DOC The Cross-Border Common Format Letter of Agreement
Aircraft Performance Mix limits capacity	Design different SIDs for high and low performance aircraft.	Airspace Design
Aircraft Navigation Performance Mix limits capacity by increasing ATC workload	ATC system modification to allow FDPS/RDPS to show aircraft navigation capability	Software Application Change
Inadequate Navigation infrastructure	New DME at Location A	Enhance NAV infrastructure
High mix of IFR-VFR movements limits capacity	SEGREGATED VFR/IFR ROUTES	Airspace Design
Fixed-wing/Rotor craft mix increases approach workload and complexity	Separated routes based on aircraft category	Airspace design
TSA which adversely affects traffic patterns	Airspace sharing arrangements	Flexible Use of Airspace Concept and EUROCONTROL DOC The Cross-Border Common Format Letter of Agreement
Poor Radar Coverage prevents route placement in part of the Terminal Airspace	Improve Surveillance capability	Enhance Radar infrastructure
Poor Radio Coverage adversely affects route placement in part of the Terminal Airspace	Improve Radio Coverage	Enhance communications infrastructure
Severe weather disrupts traffic, especially at peak times	Create 'contingency' routes for poor weather operations; re-locate holding patterns	Airspace design
No flights permitted over Village X	Diverge departure routes as soon as possible after take-off	Airspace design
Flights over City Y not permitted below 10,000 feet	Continuous Descent Approach	Airspace design and Level constraints in procedures

Activity 6

PLAN



Cost vs. Benefit Mixed mode or Mandate?

- **PBN raises the important questions: Is it necessary to mandate PBN aircraft equipage for operation along PBN ATS routes and/or SIDs/STARs?**
- **The alternative of a mandate is allowing a mix of navigation qualifications to operate in an airspace and having dedicated ATS Routes (incl. SIDs/STARs) for particular PBN qualifications. This is called 'mixed mode'.**
- **Evidence repeatedly shows that mixed mode difficult to manage in en route and terminal operations. Controllers usually end up radar vectoring everyone**

Activity 6



PLAN

Cost vs. Benefit Mixed mode or Mandate?

Phased Implementation of a NavSec is a more popular solution with airspace user, but creates mixed mode. Difficult for ATC to manage effectively without careful airspace design consideration & well defined operating procedures

Result : Different PBN Aircraft qualifications permitted in an airspace

Mandates of airborne equipment are the favoured option for efficient ATM.... But can be costly for airspace users (esp, if mandate is too demanding)

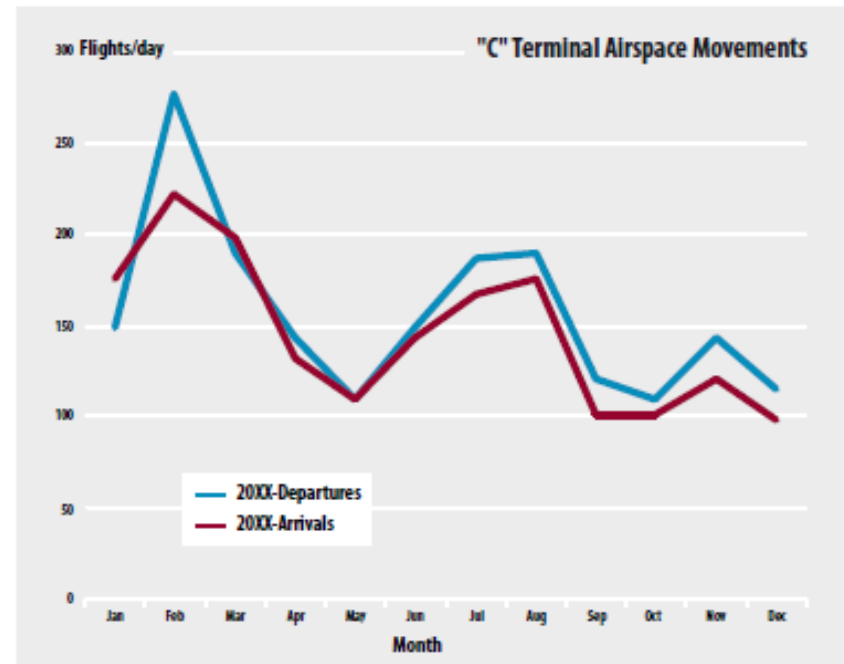
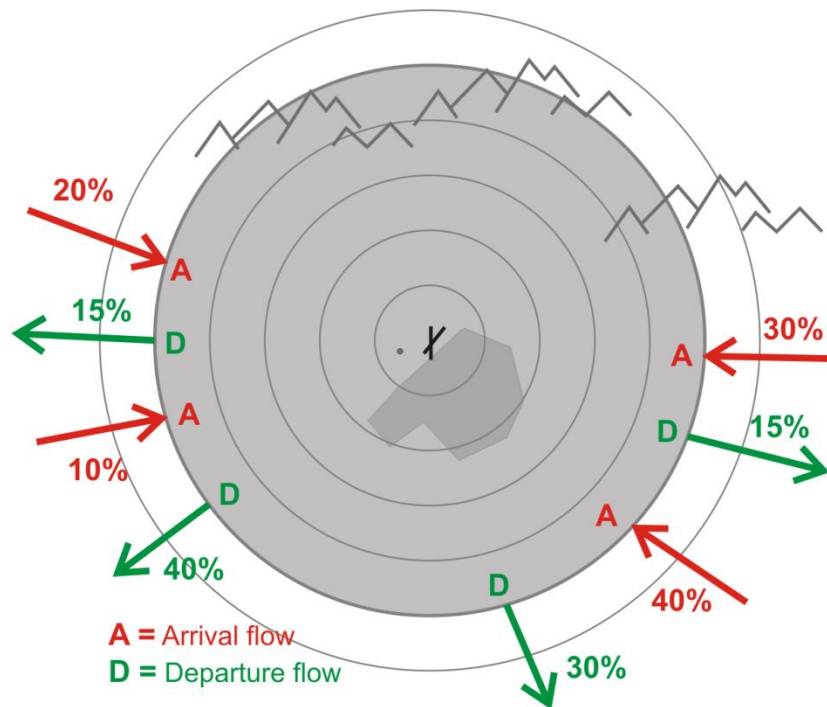
Result Only same PBN Aircraft qualifications permitted in an airspace

Activity 7

DESIGN



Design the Airspace, Routes and Holds



Activity 7

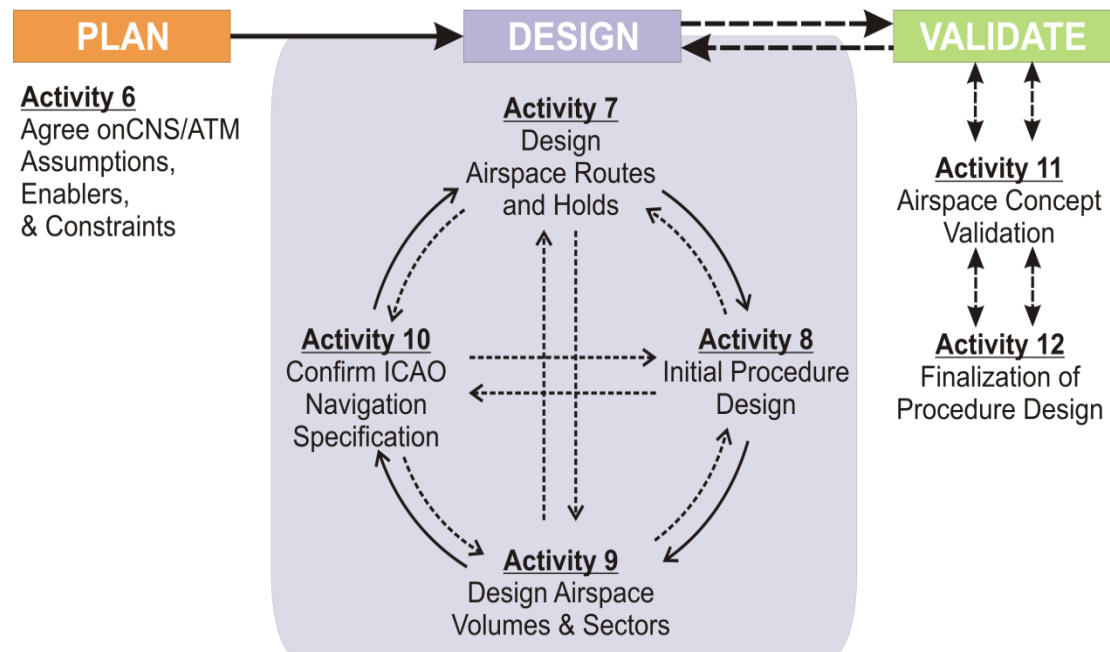


DESIGN

Design the Airspace, Routes and Holds

- 1st Design Routes
- 2nd Initial Procedure Design Analysis
- 3rd Define the airspace volumes and sectorise these, if needed

Iterations necessary!



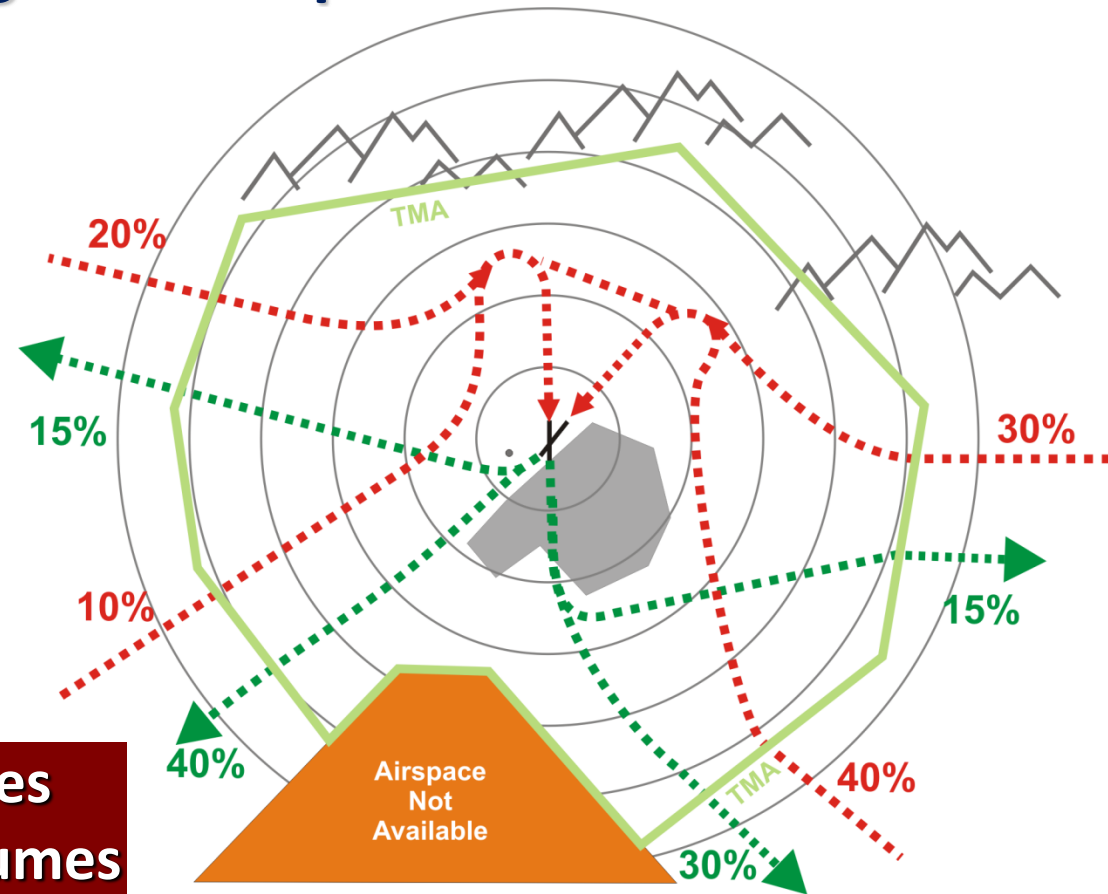
Activity 7



DESIGN

Design the Airspace

- Arrivals
- Departures
- Transit
- VFR
- Military



AVOID trying to fit the routes into the existing airspace volumes

Activity 8

DESIGN



Initial Procedural Design

- ❖ **Capability/functionality needed?**
- ❖ **Fleet capability/functionality available?**
- ❖ **Coverage provided by available Navaid infrastructure?**
- ❖ **Design according to ICAO Doc 8168 and Doc 9905**
 - **Initiation**
 - **Collect & Validate Data**
 - **Create Conceptual Design**
 - **Review by Stakeholders**

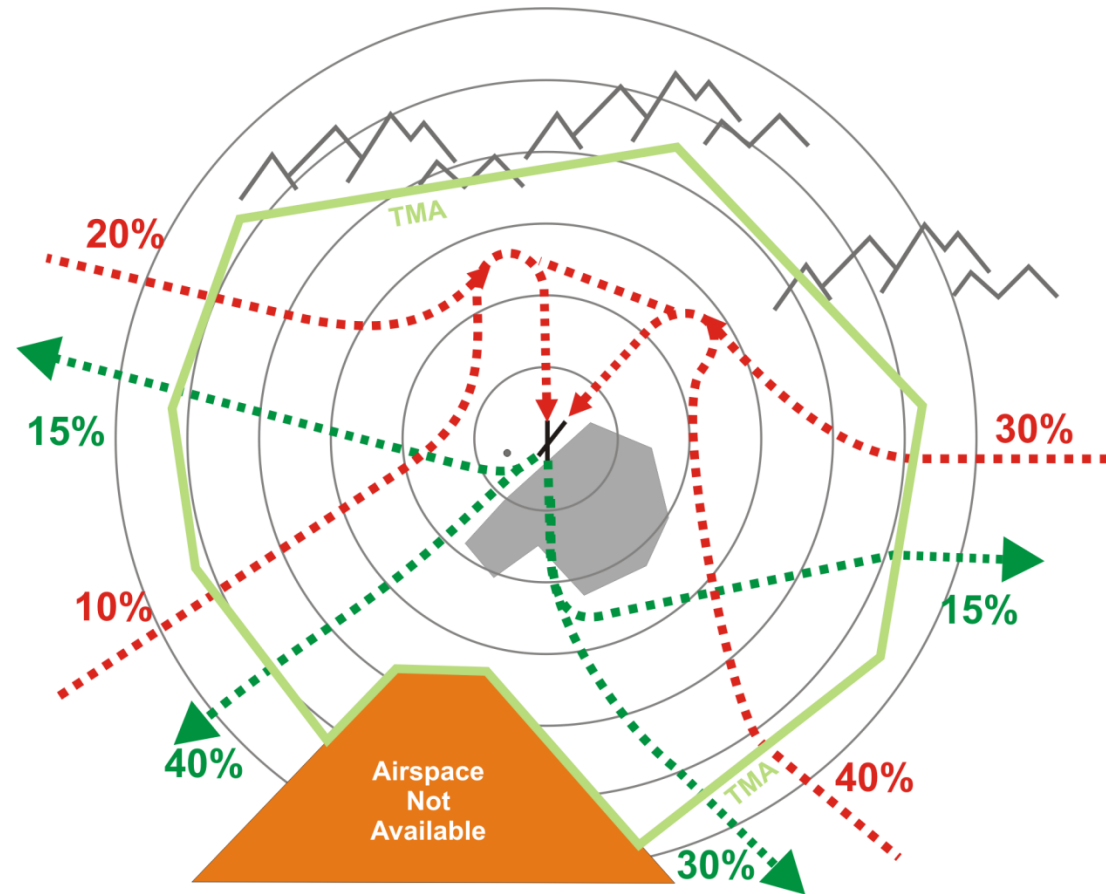
Activity 9



DESIGN

Design Airspace Volumes and Sectors

- Sectorisation
- Airspace volume
- Iterations possible



Activity 10

VALIDATE



Confirm ICAO Navigation specification

- **Review NAV specs**
- **Identify appropriate spec**
- **Go to Validation and Implementation**
- **If no appropriate spec**
 - **Apply Trade off**

Activity 11

VALIDATE



Airspace Concept Validation

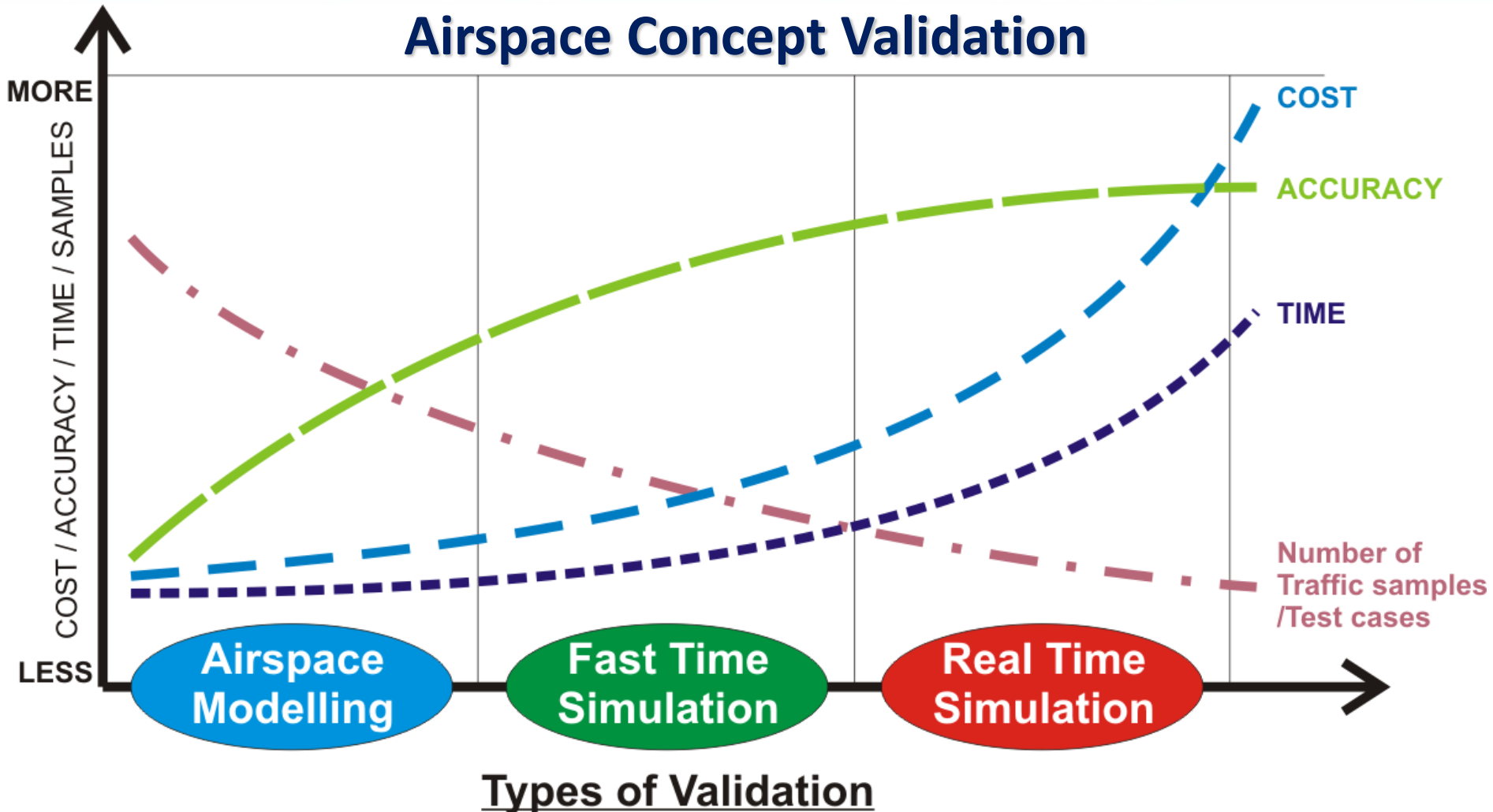
- **Prove ATM operability & validity**
- **Assess objectives**
- **Identify possible weak points**
- **Provide evidence and proof to support
Safety Assessment**

Activity 11

VALIDATE



Airspace Concept Validation



Activity 12

VALIDATE



Finalisation of procedure design

- ❖ **Design according to ICAO Doc 8168 and Doc 9905**
 - **Apply Criteria**
 - **Document and Store**
 - **Support Safety Assessment**
- ❖ **Output:**
 - **Draft procedure layouts**
 - **Calculation outputs**
 - **Textual description of procedure**

Activity 13

VALIDATE



Procedure validation

- **Verification of terrain, obstacle and aeronautical data used to support design**
- **Validate intended use of procedure (match to conceptual design)**
- **Validate correct application of criteria**
- **Validate flyability and human factors (charting)**
- **Flight Inspection (if required)**

Activity 14

IMPLEMENT



ATC System Integration

- ❖ **Changes to ATC system interfaces and displays to ensure controllers have the necessary information on aircraft capabilities and the appropriate displays to support the new routings. Such system changes could include modifications to:**
 - **Air Traffic Flight Data Processor (FDP)**
 - **Air Traffic Radar Data Processor (RDP)**
 - **ATC situation display**
 - **ATC support tools**

Activity 15

IMPLEMENT



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.**
 - **Printed training packages**
 - **Computer based training**
 - **NOTAMS**
 - **ICAO provides additional training material and seminars.**

Activity 16

IMPLEMENT



Implementation

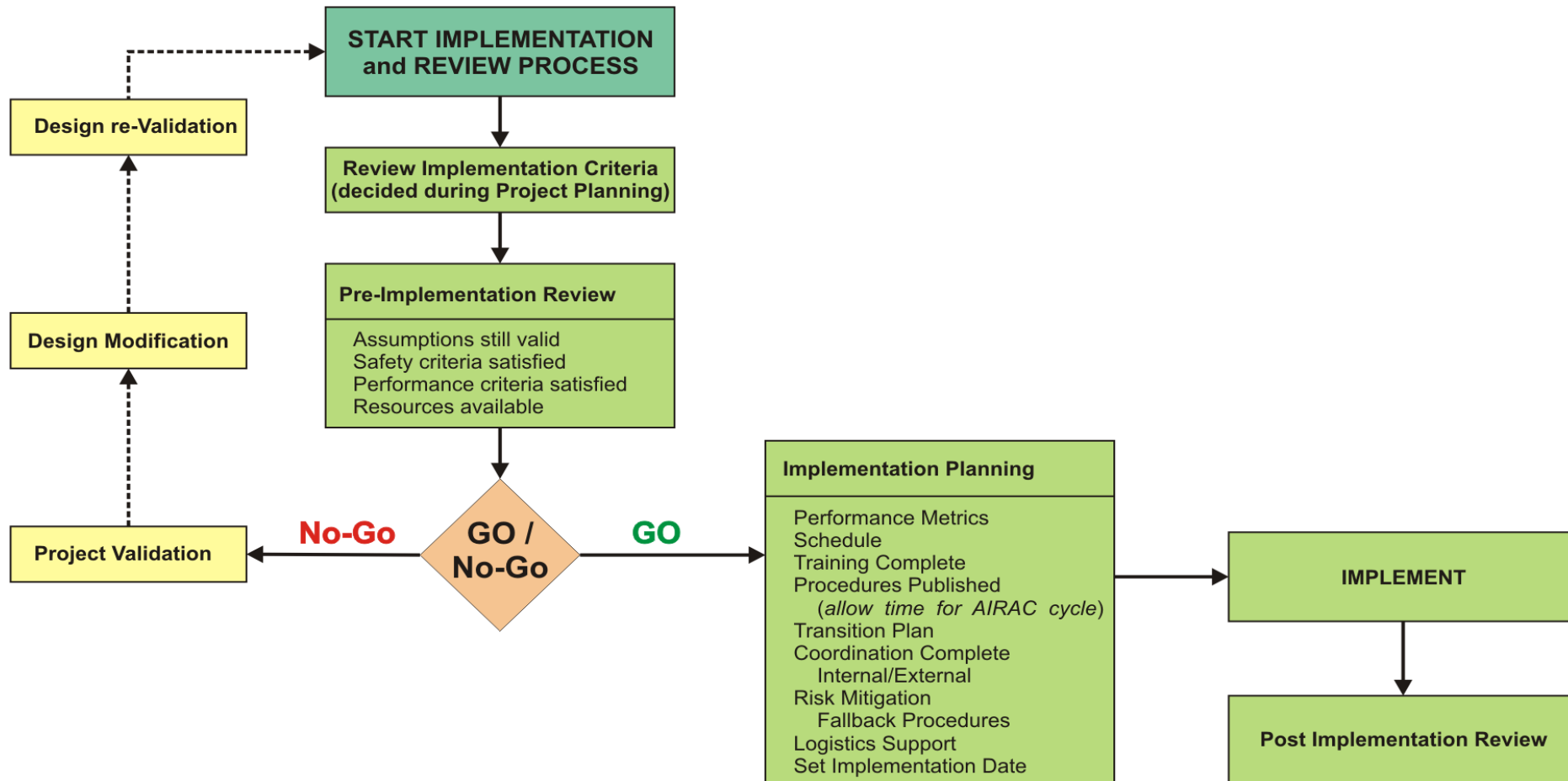
- **Have the Safety and Performance Criteria been satisfied;**
- **Have the required changes been made to the ATM system;**
- **Have the required changes been made to the ground navigation systems;**
- **Do the assumptions and conditions upon which the Airspace Concept has been developed still pertain. (are traffic flows as forecast, is the fleet suitably equipped and approved etc);**
- **Are the critical enablers all in place.;**
- **Have the pilots and controllers received appropriate training.**

Activity 16

IMPLEMENT



Implementation



Activity 16

IMPLEMENT



Implementation

- **Monitor the implementation process;**
- **Support the Centre supervisor/Approach Chief or Operational Manager should it become necessary to use redundancy or contingency procedures;**
- **Provide support and information to operational controllers and pilots;**
- **Maintain a record of implementation-related difficulties for use in future project planning;**

Activity 17

IMPLEMENT



Post Implementation Review

❖ Keep LOG

- Assess if objectives are met
- Measure!
- System safety assessment – collect evidence



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South American
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ICAO
Headquarters
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Western and
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Questions?



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Thank You