PBN
AIRSPACE CONCEPT WORKSHOP

VALIDATION AND IMPLEMENTATION CONSIDERATIONS

Federal Aviation Administration

EUROCONTROL

VALIDATION & IMPLEMENTATION

OBJECTIVE

This module provides an overview airspace and Flight Procedure validation. It addresses Implementation considerations for PBN Airspace Concepts

Addressing

WHY do VALIDATION

- Validate Airspace concept and resulting Procedure
- Assess if ATM objectives are achieved
- Confirm flyability of Instrument Flight Procedures
- Identify possible problems and develop mitigations
- Provide evidence design is safe
- Validation is an ongoing process

CAUTION

RUBBISH IN RUBBISH OUT!!!

Validation methods

Airspace

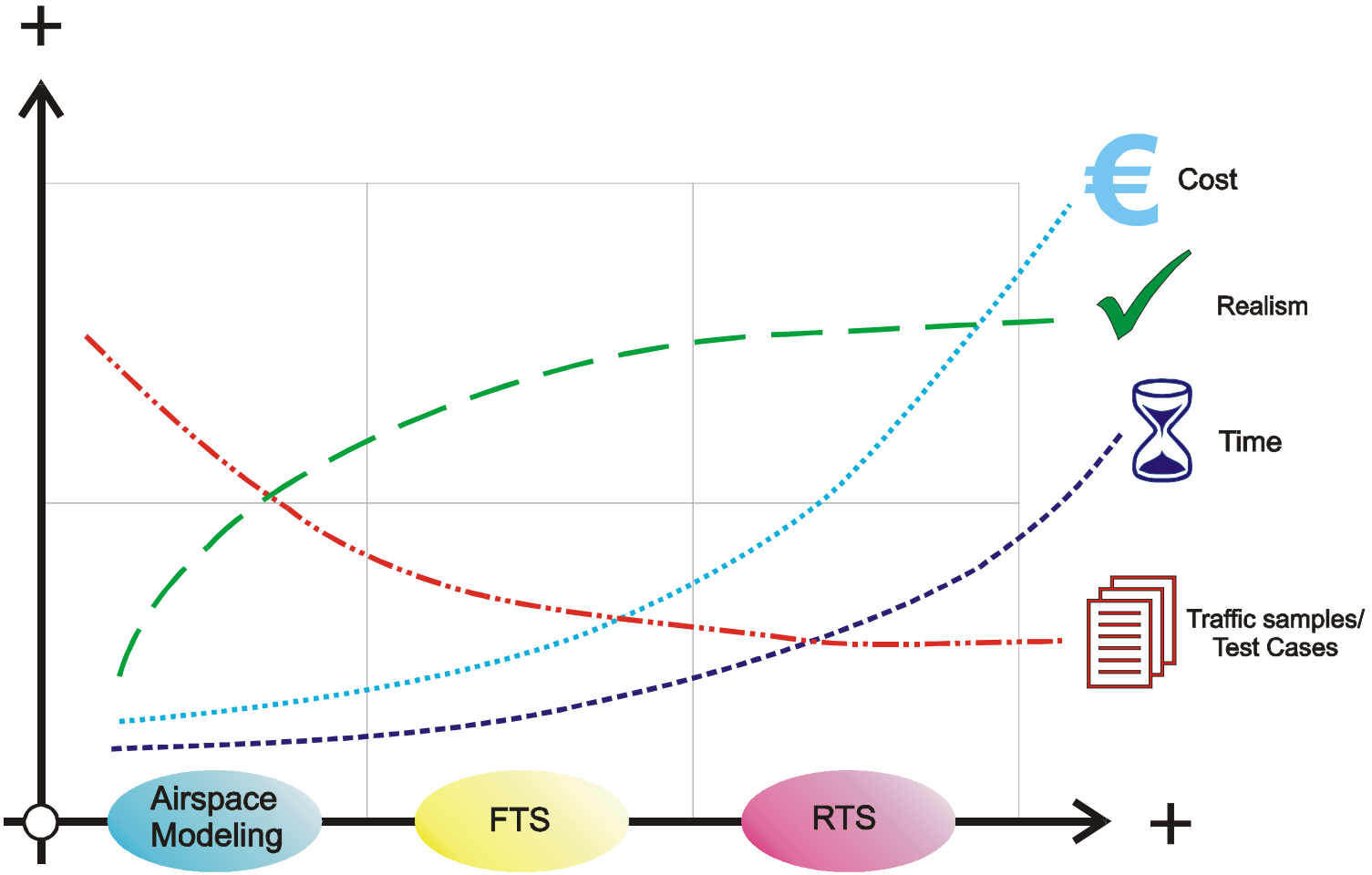
- Chalk and talk
- modelling
- FTS
- RTS

Flight Procedures

- Ground checks
- PC based simulation
- Flight simulators
  - FMS simulator (Smiths)
- Live trials

CHALK and TALK

Airspace Concept Validation



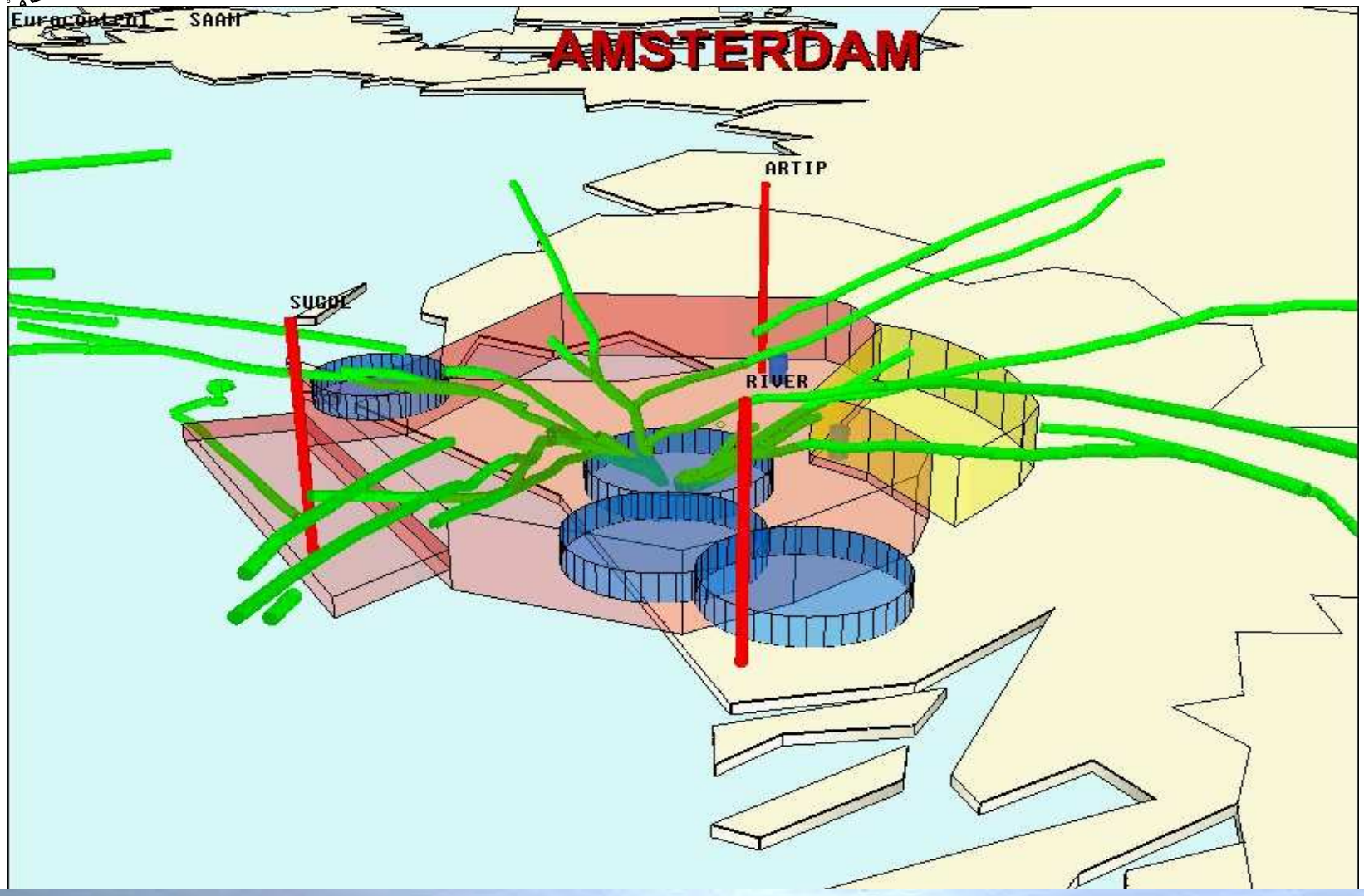
Airspace Concept Validation

- General Considerations
  - Aircraft performance
  - Sterile environment
  - Special events

AIRSPACE modelling advantages

- Great flexibility
- Simple
- What if investigations
- easy to test large number of traffic samples
- data derived from real traffic and ATC environment

EXAMPLE



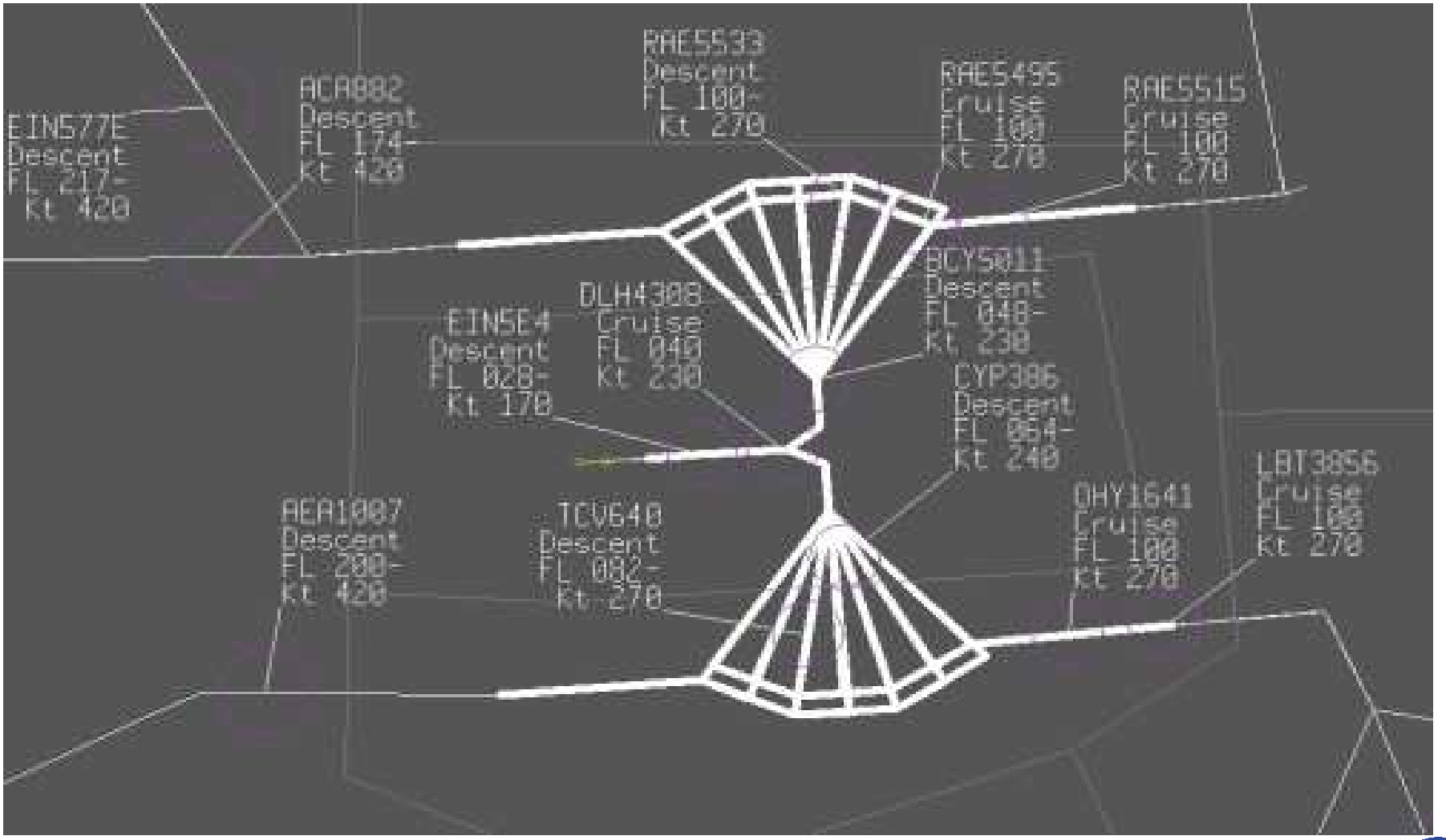
AIRSPACE modelling disadvantages

- Crude
- Only high level data
- Basic aircraft performance
- Does not replicate controller interventions
- Simplified
- subjective

FTS

- Used for sector capacity
- Quality data
- Flexible
- Good acceptance of results
- Evaluate TLS
- Used for Safety Case

FTS


RAE5533
Descent
FL 100-
Kt 270
ACA882
Descent
FL 174-
Kt 420
RAE5495
Cruise
FL 100
Kt 270
RAE5515
Cruise
FL 100
Kt 270
EIN577E
Descent
FL 217-
Kt 420
BCY5011
Descent
FL 048-
Kt 230
DLH4308
Cruise
FL 040
Kt 230
EIN5E4
Descent
FL 028-
Kt 170
CYP386
Descent
FL 064-
Kt 240
LBT3856
Cruise
FL 100
Kt 270
AEA1087
Descent
FL 200-
Kt 420
TCV640
Descent
FL 082-
Kt 270
OHY1641
Cruise
FL 100
Kt 270

FTS

- Simplified model
- Only statistical data
- No active controller interaction during FTS
- Accuracy of models is key
- Aircraft performance
- Met conditions

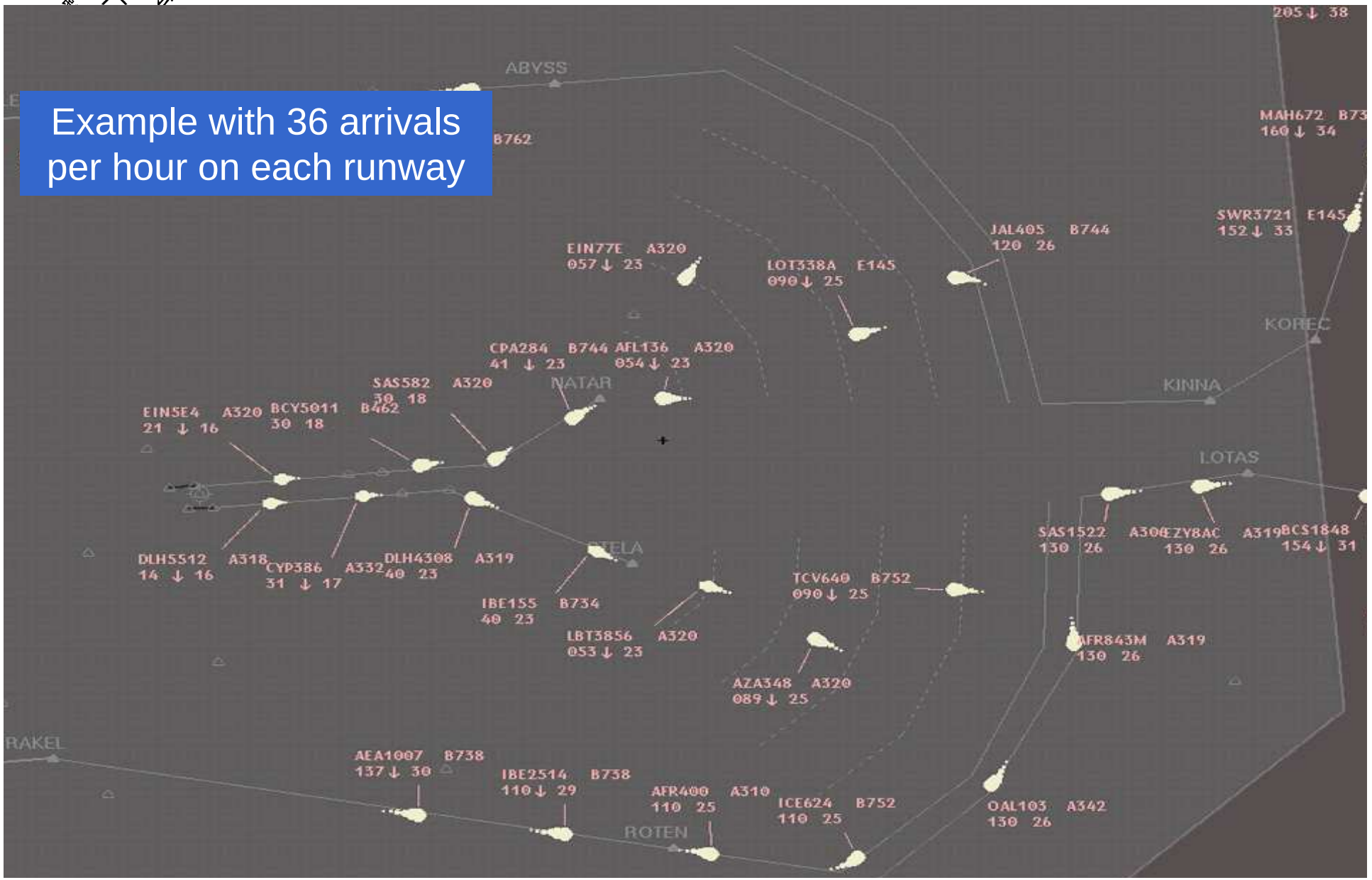
Research RTS

- Best method to simulate ATC trials
- High quality data
- Feed controllers/ pseudo pilots
- Human factor
- Can be part of Safety Case
- No risk to live ops
- Unlimited scope

Training Real Time Simulator

- Limited scope
- Designed for training ATC
- Aircraft performance not representative
- HMI
- Not designed for post simulation evaluation needed for Airspace concept evaluation

EXAMPLE


Example with 36 arrivals per hour on each runway
ABYSS
NATAR
KINNA
KOREC
LOTAS
RAKEL
ROTEN
B762
EIN77E A320 057↓23
LOT338A E145 090↓25
JAL405 B744 120 26
CPA284 B744 41↓23
AFL136 A320 054↓23
SAS582 A320 30 18
EIN5E4 A320 21↓16
BCY5011 B462 30 18
DLH5512 A318 14↓16
CYP386 A332 31↓17
DLH4308 A319 40 23
IBE155 B734 40 23
LBT3856 A320 053↓23
TCV640 B752 090↓25
AZA348 A320 089↓25
SAS1522 130 26
A306
EZY8AC 130 26
A319
BCS1848 154↓31
AFR843M A319 130 26
AEA1007 B738 137↓30
IBE2514 B738 110↓29
AFR400 A310 110 25
ICE624 B752 110 25
OAL103 A342 130 26
MAH672 B73 160↓34
SWR3721 E145 152↓33
205↓38

FLIGHT SIMULATOR

- High quality data
- Confirm design aspects
  - Fly-ability
  - Efficiency
  - Met impact
- Possible link to RTS

FLIGHT SIMULATOR

But

- Manual data collection
- For range of aircraft types/meteo conditions time consuming and expensive
- Pilots

Live ATC trials

- Most accurate
- Real data
- Feedback from all users

But

- Safety
- High detail required – large effort for a concept evaluation
- Limited scope
- Limited flexibility

Procedure Validation

Procedure Validation

- Ground Validation
  - Obstacle clearance
  - Charting
  - Coding
  - Flyability
- Flight Validation
  - Obstacle verification (optional)
  - Flyability (workload, charting, manoeuvring)
  - Infrastructure
- Database Validation

Ground Validation

- Obstacle clearance
  - Independent review by procedure designer
- Charting
  - Independent review

Independent review – can be part of same organisation

- Coding
  - Software tool (e.g. Smiths PDT) or
  - Expert review
- Flyability – software tools (from PC-based to full flight simulator)
  - Not necessarily an issue with standard procedures (e.g. 'T' approaches), but critical for some aircraft types
  - Range of aircraft and meteo conditions

Ground Validation: Validate the Procedure

- Independent assessment
- Use of validation tools
- Use of aircraft simulators
  - more than one type
- Flight checks
- Initial operational checks

Ground Validation: Validate the Procedure Flyabilty

Procedure Editor for *BULT1Z

Airport: EBBR Loaded NDB: TST1-0101-01

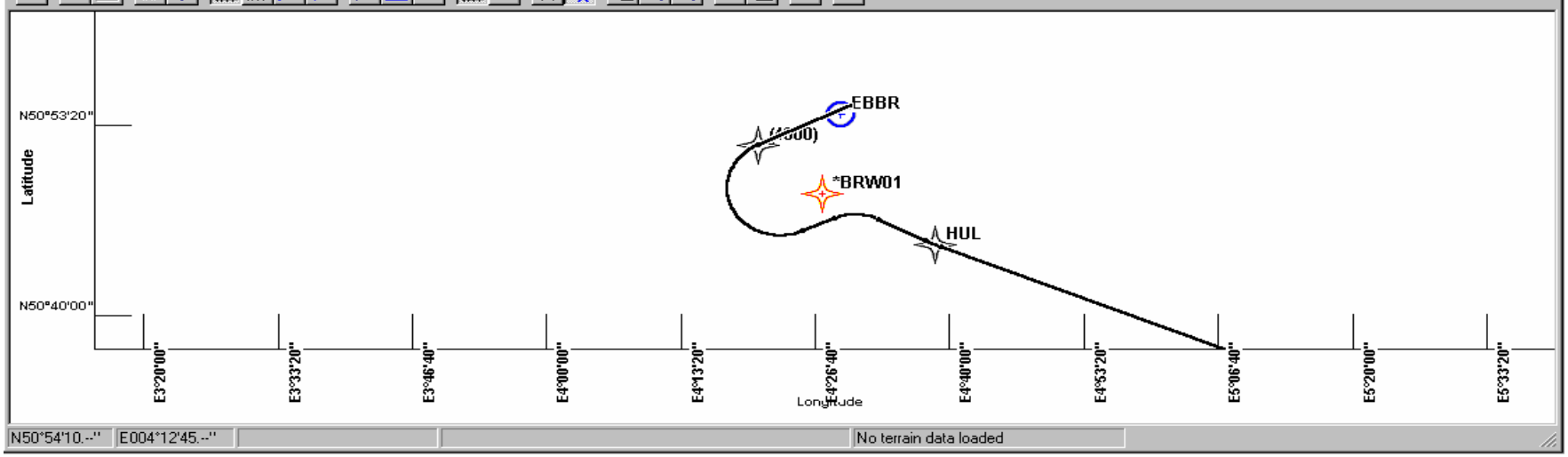
Proc Type: SID User NDB: Test.ndb

Procedure checks out OK

Procedure Id: *BULT1Z Transition Alt: 4500

TYPE	IDENT	PTH/TRM	TO FIX	WP DESC	HDG/CRS	TURN DIR	ALTITUDES	SPD LIM	REC NAV	T/D/R	FIX RAD	VERT ANG	ARC CTR	RNP
BASE	RW25R	FA	RW25R	G	246		4000		BUB					
BASE	RW25R	CF	*BRW01	E	150				HUL					
BASE	RW25R	TF	HUL	E			6000							
BASE	RW25R	TF	BULUX	E			+ 17000							
BASE	RW25R	TF	BULTO	EE										

Plot Window for : EBBR -> EBBR



Ground Validation: Validate Again with Different Conditions

Procedure Editor for *BULT1Z

Airport: EBBR Loaded NDB: TST1-0101-01

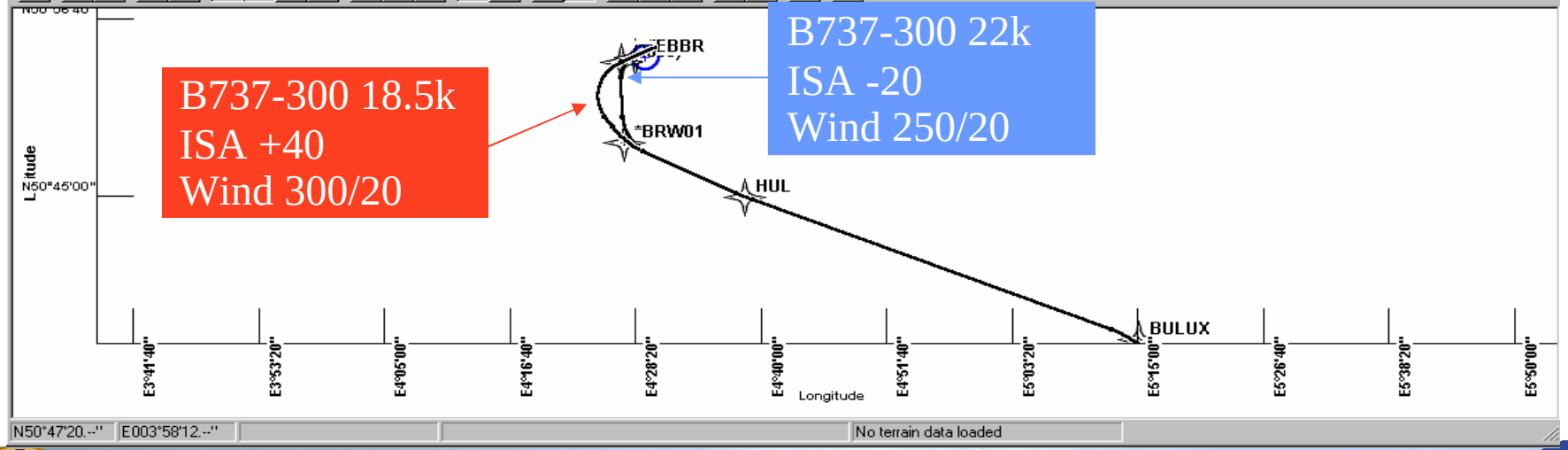
Proc Type: SID User NDB: Test.ndb

Procedure checks out OK

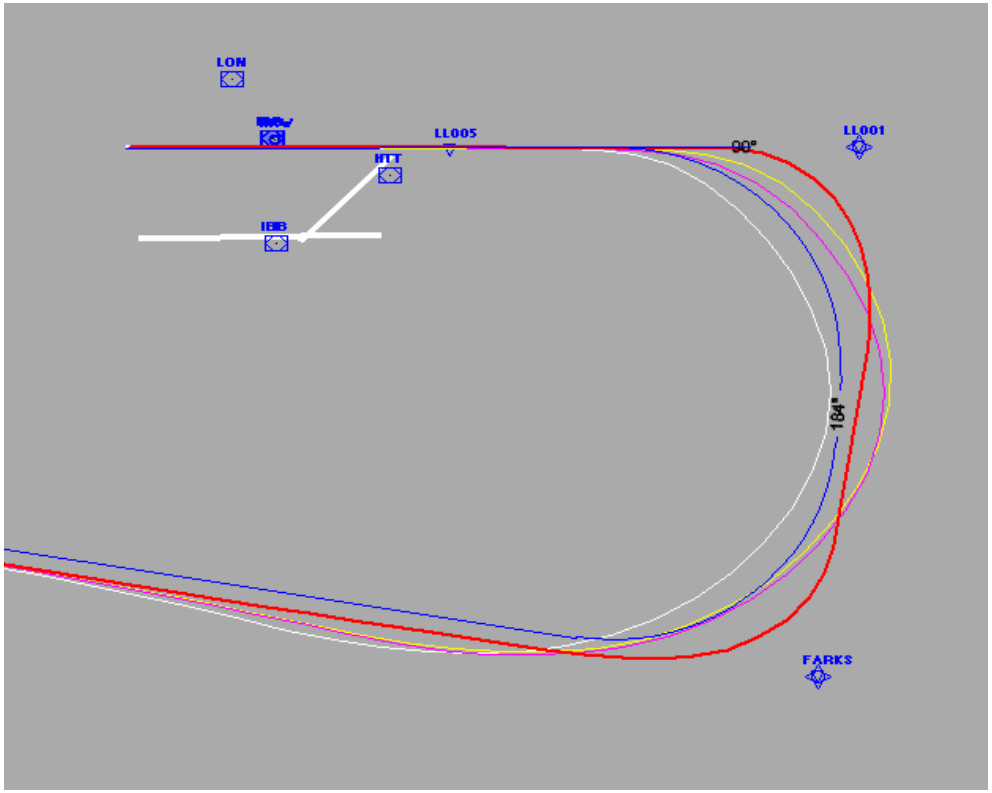
Procedure Id: *BULT1Z Transition Alt: 4500

TYPE	IDENT	PTH/TRM	TO FIX	WP DESC	HDG/CRS	TURN DIR	ALTITUDES	SPD LIM	REC NAV	T/D/R	FIX RAD	VERT ANG	ARC CTR	RNP
BASE	RW25R	FA	RW25R	G	246		2000		BUB					
BASE	RW25R	DF	*BRW01	E										
BASE	RW25R	TF	HUL	E			6000							
BASE	RW25R	TF	BULUX	E			+ 17000							
BASE	RW25R	TF	BULTO	EE										

Plot Window for : EBBR -> EBBR



Ground Validation: Different Aircraft and Different Conditions



CA 500ft agl; DF LL001; TF FARKS; TF…

No wind

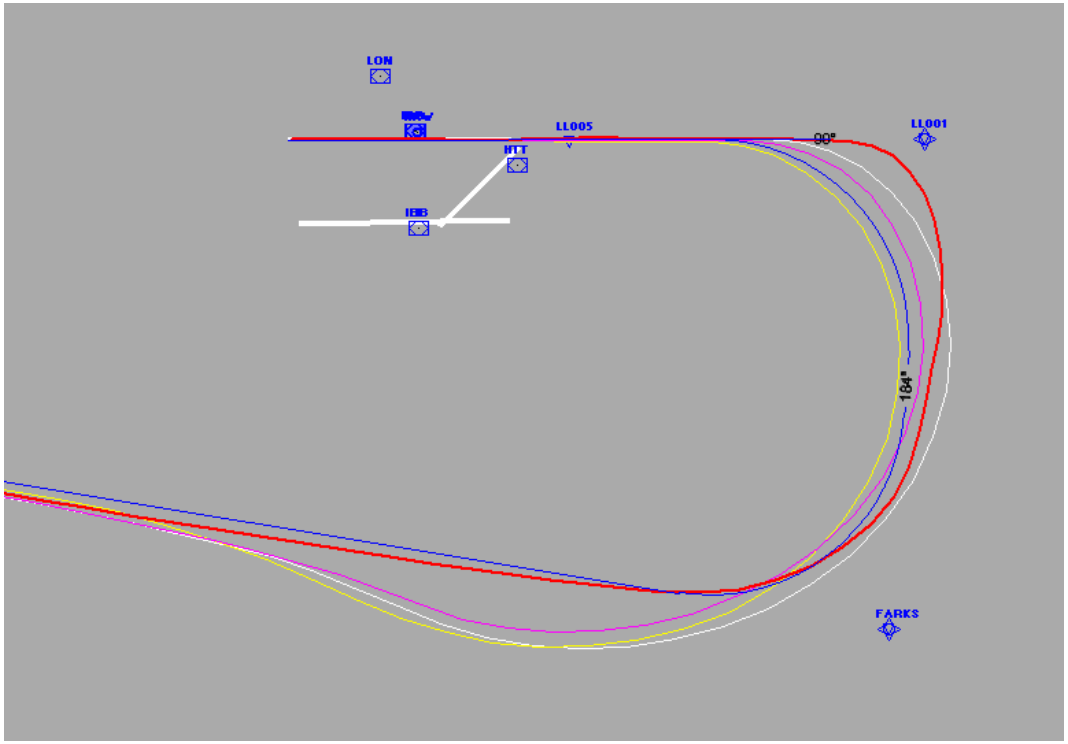
A319

B737/400

B747/400

A340/300

Ground Validation: Wind Effect



CA 500ft agl; DF LL001; TF FARKS; TF…

ICAO wind from 045°

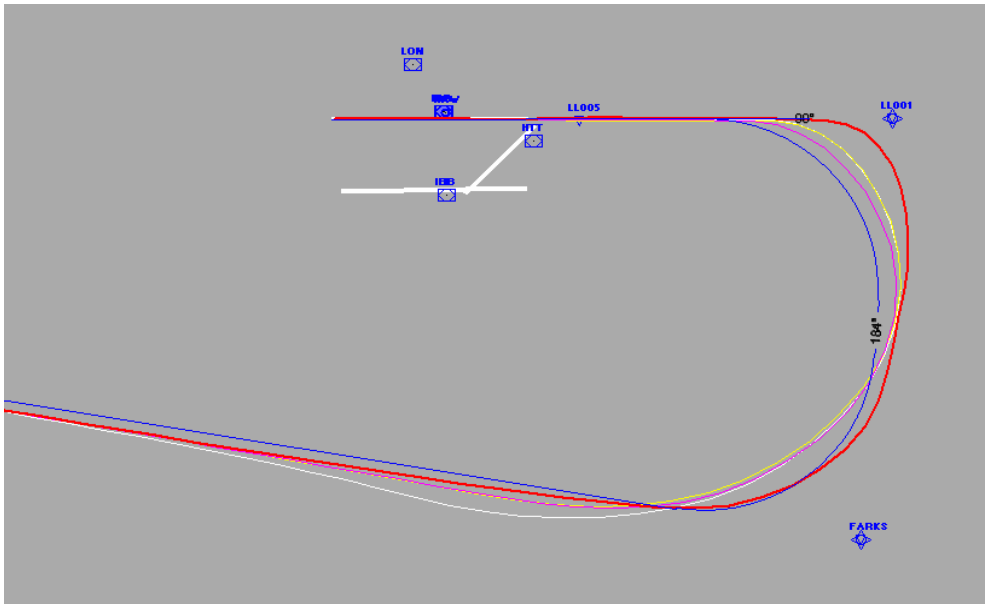
A319

B737/400

B747/400

A340/300

Ground Validation: Countered by Speed Restriction



CA 500ft agl; DF LL001; TF FARKS [210kts]; TF…

ICAO wind from 045°

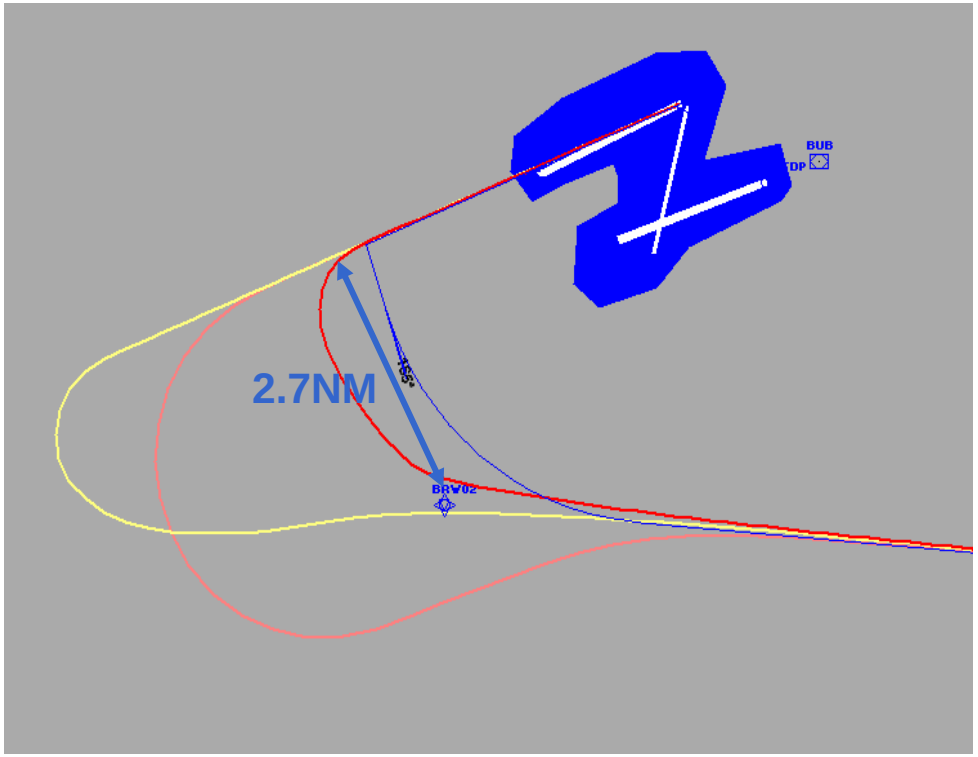
A319

B737/400

B747/400

A340/300

Ground Validation: Leg Length Too Short



CA 2000ft agl; DF BRW02

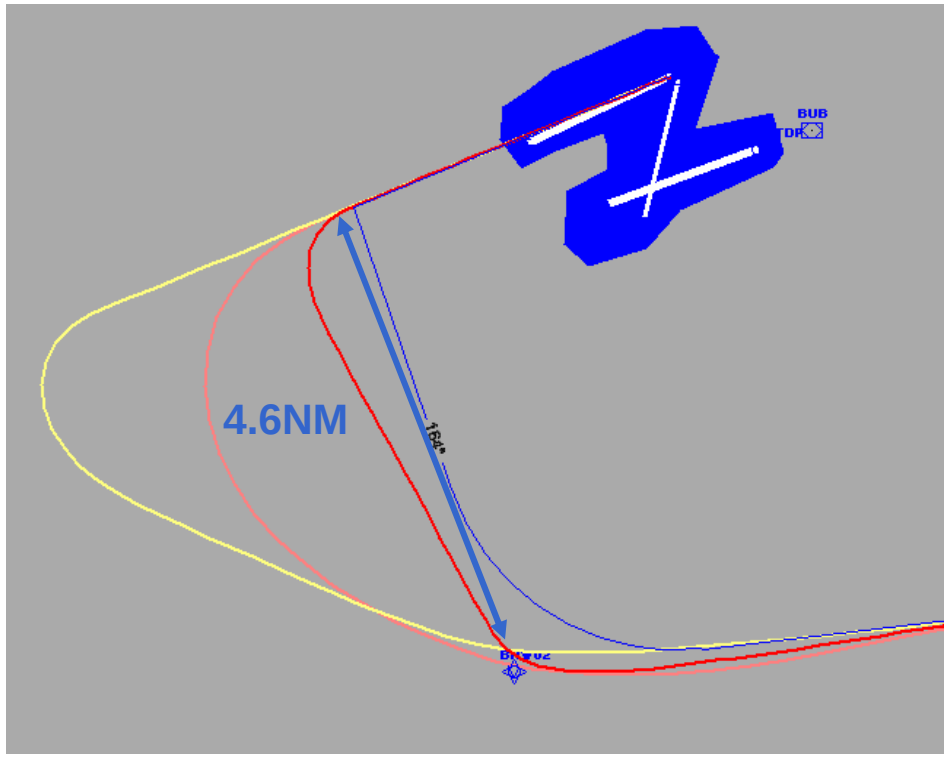
No wind

ATR42

B 747-400

A340-300

Ground Validation: Leg Length Acceptable



CA 2000ft agl; DF BRW02

No wind

ATR42

B 747-400

A340-300

Flight Validation

- Obstacle verification
  - Necessary where full obstacle survey cannot be assured
- Flyability
  - Detailed workload and charting assessments, but
  - High level qualitative assessment of manoeuvring only (rely mainly on Ground Validation)
- Infrastructure assessment
  - Runway markings, lighting, communications, navigation etc

Flight Inspection

- Flight Inspection often confused with Validation
- Flight Inspection Addresses:
  - **Navaid performance** for DME/DME RNAV
  - **Unintentional interference** for GNSS
- Flight Validation does not address Navaid Infrastructure issues

Publication and Coordination with Data houses

RNAV Procedure Description

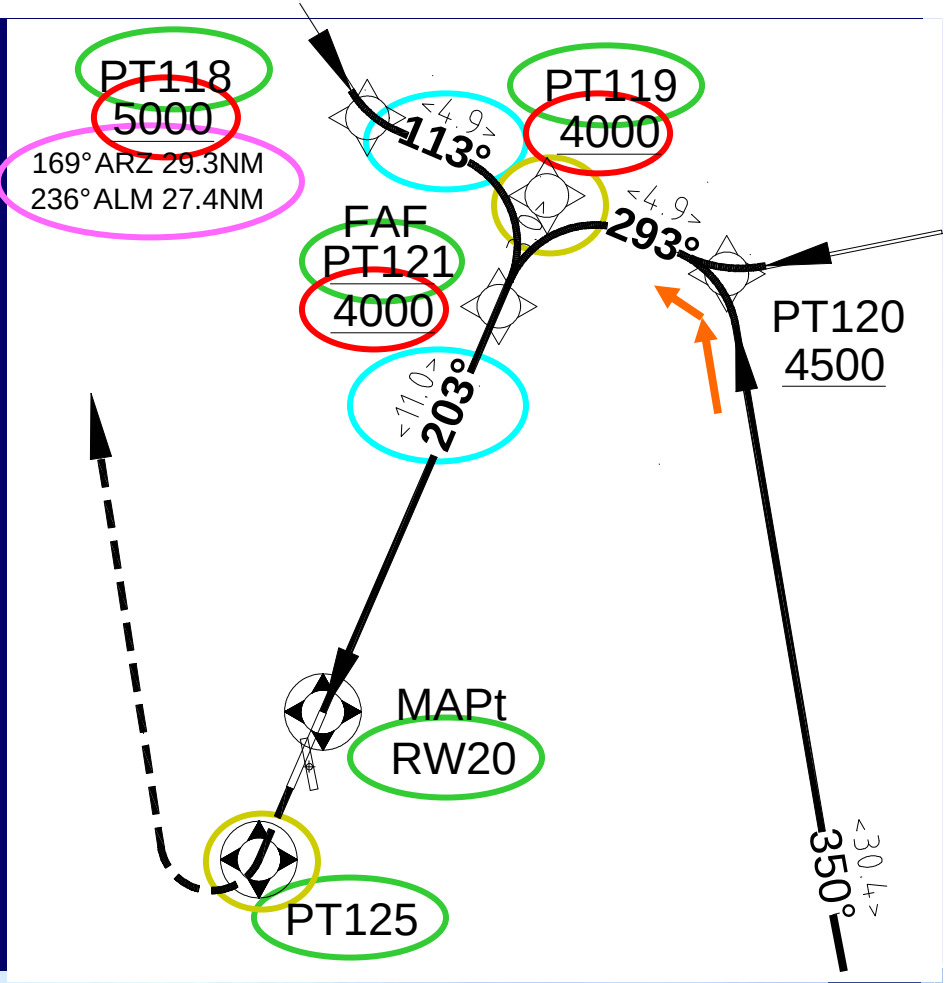
- Procedures are currently published as charts and as textual descriptions.
- The charts are used by the pilots and ATC.
- Database providers require clear, and unambiguous procedure descriptions and use the charts to validate/check.

RNAV Procedure Description

- RNAV procedures defined by:
  - Sequence of waypoints
    - Identifier
    - Co-ordinates
    - Fly-over/fly-by/fixed radius
  - Path Terminators - ARINC 424
  - Altitude restrictions
  - Speed restrictions
  - Direction of turn
  - Required navaid

Procedure Description
Information relevant to Pilots

- Waypoint sequence
- Fly-over/fly-by/fixed radius
- Speed/Altitude Restrictions
- Leg distance & magnetic track
- Fix information
- Turn direction



Procedure Description for Database Providers

- Textual description is usually used to provide formal statement of procedure.
  - Often open to interpretation.
- RNAV procedures require more specific details including path terminators.
  - Can result in lengthy descriptions.
  - Alternative descriptive methods have been adopted by OCP:
    - Tabular layout ← preferred by data houses
    - Formalised textual description
    - Formalised short-hand description

Waypoint Identification

- Significant points
  - identified by co-located navaid or by unique five-letter pronounceable “name-code” (5LNC).
- Some waypoints (Tactical Waypoints) in the terminal area used for vectoring for sequencing and must be easy to enter in an RNAV system.
  - 5LNCs not appropriate for this (ALECS, ALEKS, ALEX).
  - No information on order in procedure for “Go Direct”.
  - Naming confusion
- IFPP introduced concept of strategic and tactical waypoints

RNAV Procedure Identification

- RNAV RWY 23
- RNAV(DME/DME) RWY 23
- RNAV(GNSS) RWY 23
- RNAV(RNP) RWY 23

Charting Altitude Restrictions

An altitude window :	FL220 10,000
An “at or above” altitude:	7000
A “hard” altitude :	3000
An “at or below” altitude :	5000

FMS/RNAV limitations

- Airspace Design often wants STARS to a metering fix and Stars to join to initial approach Fix for each runway
- Cannot have two Stars in FMS
- Airway and approach transitions needed

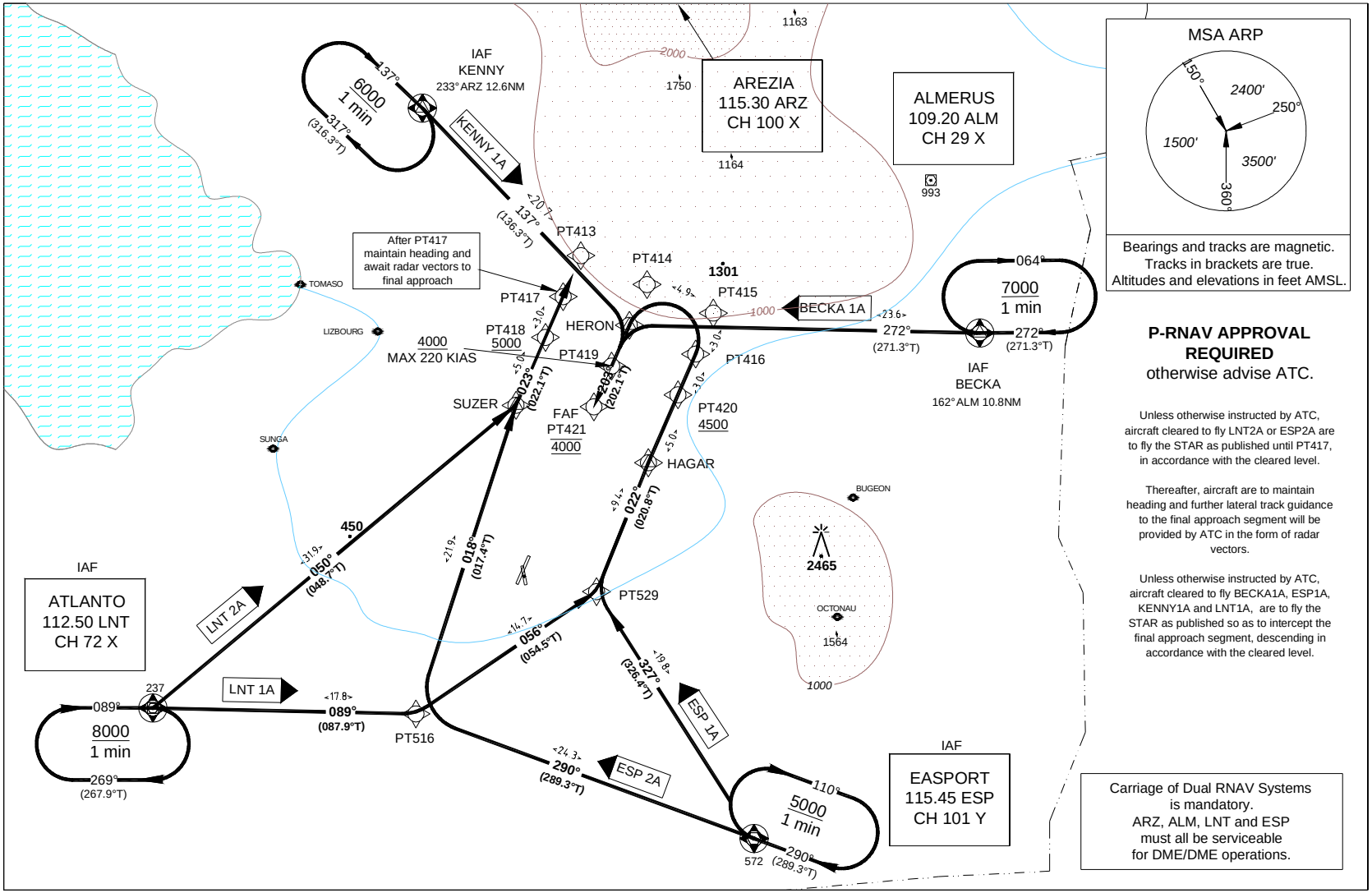
Charting: RNAV 'Transition'

PATEON
RWY 20

ATIS	121.700	TOWER	124.850
RADAR	127.950	GROUND	121.775
ARRIVAL	118.020	APRON	123.125

RNAV (DME/DME & GNSS except Class A GPS) INITIAL APPROACH

TRANSITION ALTITUDE 8000' VAR 1.0°W



Effective: 25 Feb 1999

Implementation Considerations

- Implementation decision
- PRE IMPLEMENTATION REVIEW!!!!
  - ATC system consideration
  - TRAINING
  - AIRAC

IMPLEMENTATION

- Monitor process
- Support OPS
  - Redundancy or contingency procedures
- Support controllers and pilots
- Keep LOG system

DO NOT FORGET

- POST IMPLEMENATION ASSESSMENT
  - Objectives met
  - Safety issues
  - Improvements
  - Quality process

LESSONS LEARNED

- B-RNAV
  - Phased
  - Connectivity
- P-RNAV
  - Chicken and the egg
  - Capable versus approved
- TMA projects

THANK YOU

Tabular Description

RNAV Approach

Path Terminator	Waypoint Name	Fly Over	Course/Track/ Heading ºM (ºT)	Turn Direction	Altitude Constraint	Speed Constraint	Required Navaid	Bearing/ Range to Navaid	VPA/ TCH
IF	SUSER	-	-	-	+5000	250	-	LOM 262/29	-
TF	CV023	-	-	-	4000	-	-	-	-
CF	CV024	-	348º (347.8º)	-	2680	150	OKE	-	-
TF	RW35L	Y	-	-	370	-	-	-	-3º/50
FA	RW35L	-	348º (347.8º)	L	770	-	OKE	-	-
DF	SUSER	Y	-	-	5000	-	-	-	-

RNAV SID

Path Terminator	Waypoint Name	Fly Over	Course/Track/ Heading ºM (ºT)	Turn Direction	Altitude Constraint	Speed Constraint	Required Navaid	Bearing/ Range to Navaid	Vertical Path Angle
FA	RW20	-	201º (203.3º)	R	400	-	-	-	-
DF	FOKSI	-	-	-	-	250	-	-	-
TF	PF213	Y	345º (346.8º)	-	+5000	250	-	OKE 330/30	-

Strategic Waypoint

- A waypoint in the terminal area which is:
  - Of such significance to the ATS provider that it must be easily remembered and stand out on any display, or
  - Used as an ‘activation point’ to generate a message between computer systems when an aircraft passes it.
- Strategic waypoints are identified with 5LNCs unless they are co-located with a navaid, when the 3 letter navaid ID is used.

Tactical Waypoint

- Tactical: a waypoint which is defined solely for use in the specific terminal area and has not been designated a strategic waypoint.
- Identified as AAXNN, where:
  - AA - the last two characters of the aerodrome location indicator;
  - X - a numeric code from 0 to 9 (N, E, W and S may be used instead if a State has a requirement for quadrantal information)
  - NN - a numeric code from 00 to 99.