

## Stakeholder Views on PBN differ

**Airlines:** PBN means **increased capacity or landing availability** through improved, safe operations and airspace design, and **efficient aircraft/operations** solutions, all supported by **cost benefits**.

**States:** PBN is a tool to implement **improved airspace and operations (ICAO) globally**, while assuring safety

**Regulators:** PBN provides for increased system performance assurance, situational awareness, consistency of flight operations, and both **aircraft and operational safety**

**Industry (RTCA / EUROCAE):** PBN Standards should **make sense** for certification, provide requirements that **do not limit implementation**, provide **cost benefits**, and **support airline and airspace** requirements

# ARINC

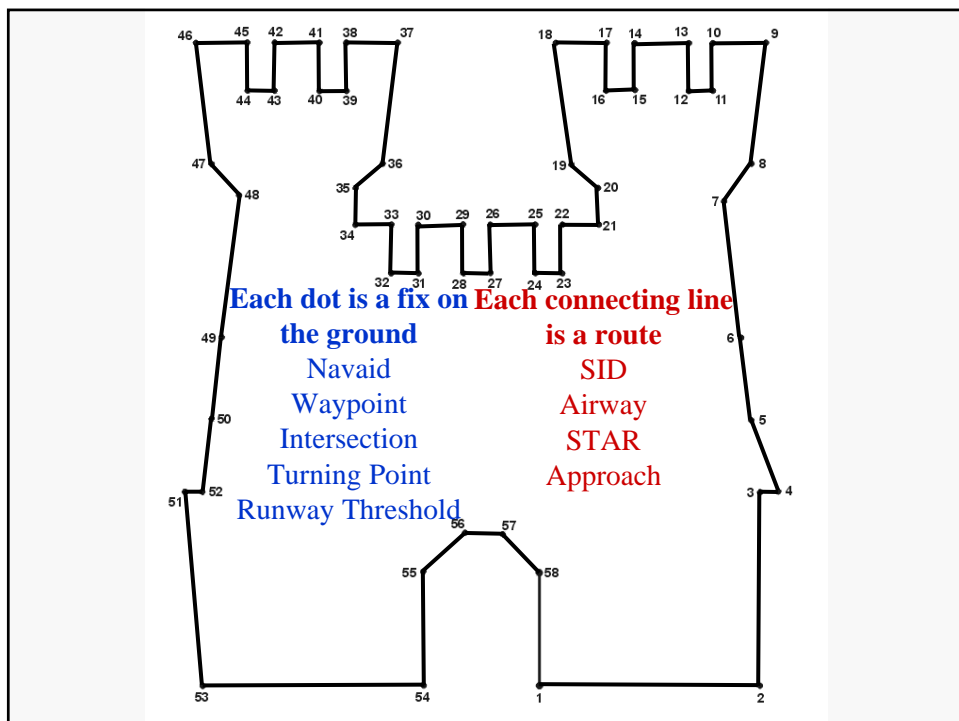
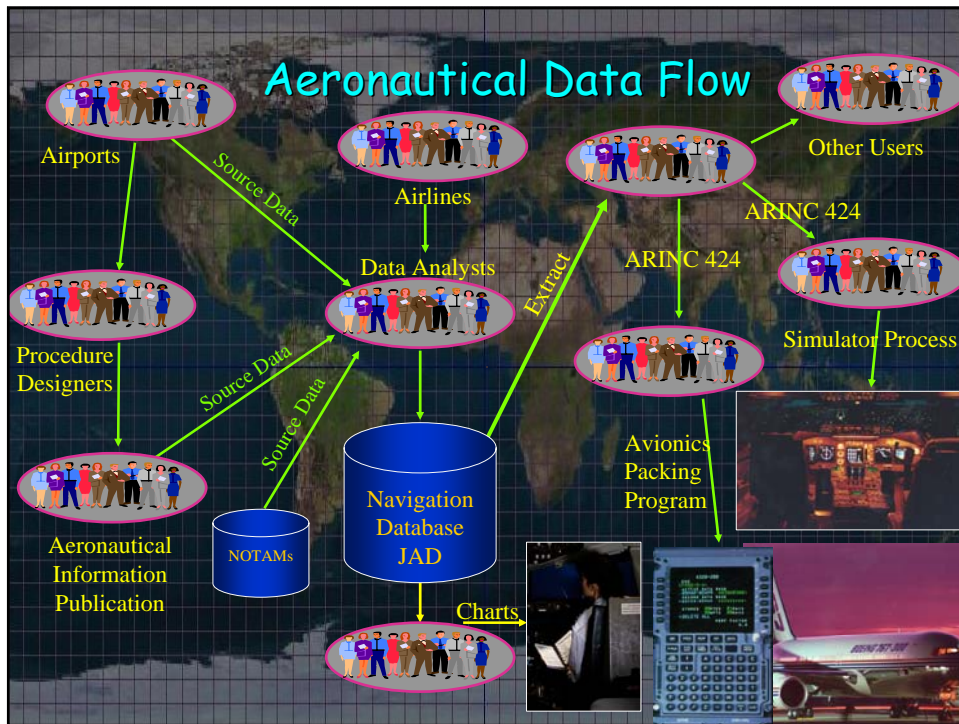
NAVIGATION SYSTEM DATA BASE

ARINC SPECIFICATION 424

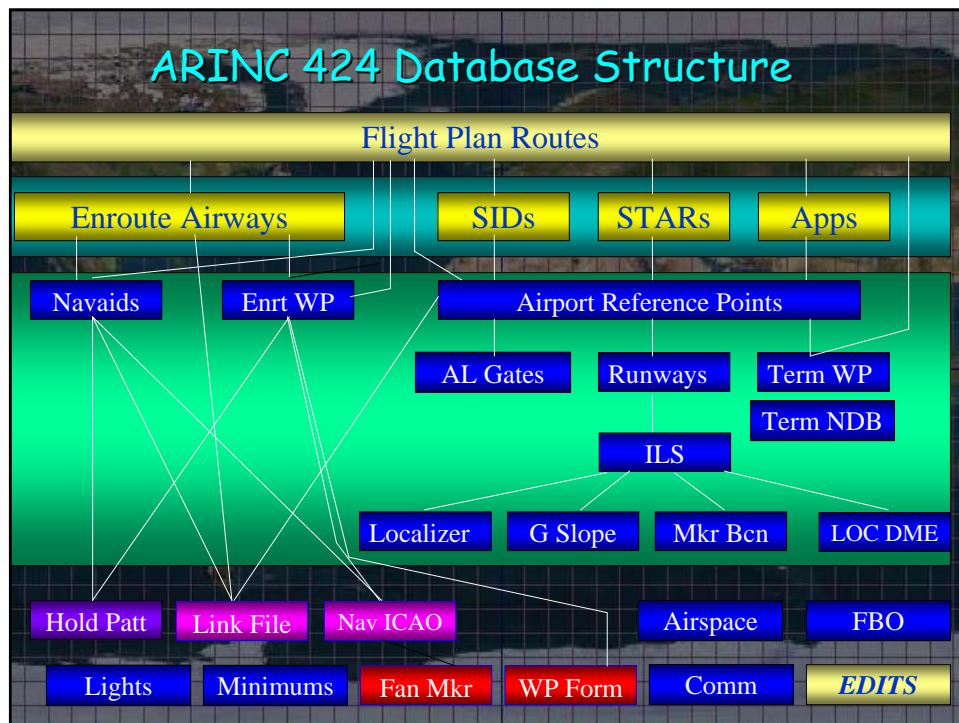
AN ARINC DOCUMENT  
PRESENTED BY  
AIRLINE ELECTRONIC ENGINEERING COMMITTEE  
FOUNDED BY  
AIRLINE ELECTRONIC ENGINEERING COMMITTEE  
3901 BVA ROAD, ANNAPOLIS, MARYLAND 21403

## ARINC 424 Worldwide Standard

- September 1973 - First ARINC 424 Meeting
- July 1975 – First Gray Cover published
- July 1976 - ARINC 424-1
- ARINC 424-3 - First "Air Mass" Application
- ARINC 424-4 - Added Simulator Capability
- ARINC 424-5 - Added Computer Flight Planning
- ARINC 424-19 – Adopted October 22, 2008
- ARINC 424-20 – Meeting March 2009 in Melbourne, Aust







# PATH and TERMINATOR

(Also known as Path/Terminators)

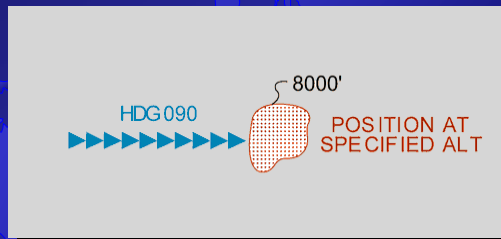
- **Describes Leg Types**
- **Path** - How do you get there - (Heading, Course, Etc.)
- **Terminator** - The event or condition that causes Leg Sequencing

ICAO RNAV Leg

One of 23 leg types



## Heading to Altitude



VA leg

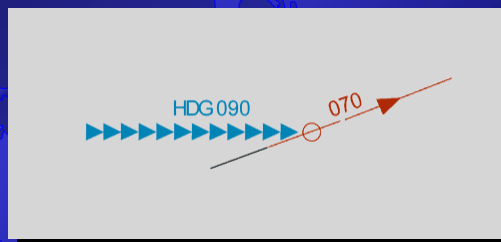
Path - Heading 090°

Terminator - 8,000 Feet

(default leg for most North American departures)

ICAO RNAV Leg

## Heading to a Next Leg Intercept



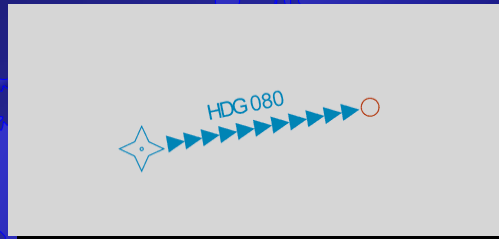
VI leg

Path - Heading 090°

Terminator - Interception of the 070°  
Course to the Next Fix

ICAO RNAV Leg

## Heading to a Manual Termination



**VM** leg

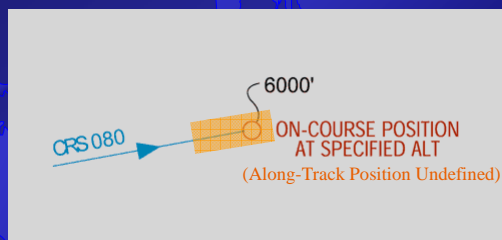
Path - Heading 080°

Terminator - Manual Termination

(Pilot must take action to terminate)

ICAO RNAV Leg

## Course to an Altitude



**CA** leg

Path - Course 080°

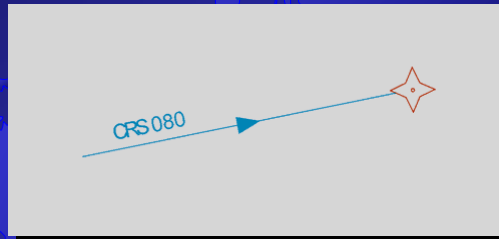
Terminator - 6,000 Feet

(default leg for most European departures)

ICAO RNAV Leg

RNP Leg

## Course to a Fix



CF leg

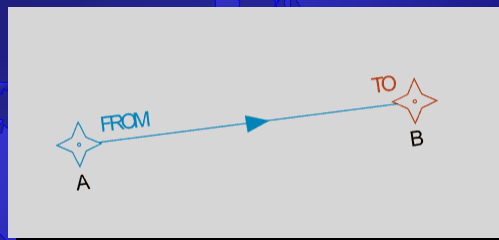
Path - Course 080°

Terminator - Crossing the Fix

ICAO RNAV Leg

Primary RNP Leg

## Track Between Two Fixes



TF leg

Path - The Great Circle

Course Between Waypoints

Terminator - Passing the "To" Waypoint

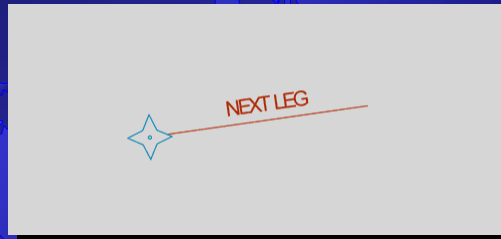
Default leg type for all enroute airways



ICAO RNAV Leg

Primary RNP Leg

## Initial Fix



**IF** leg

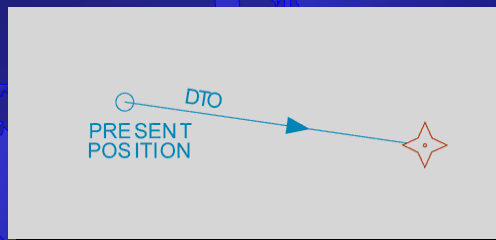
No Real Path or Terminator.

The Initial Fix Begins the Series of Records for a Procedure (SID, STAR, Approach)

ICAO RNAV Leg

RNP Leg

## Computed Track Direct to a Fix



**DF** leg

Path - The Great Circle Course from  
Present Position to the "To" Waypoint  
Terminator - Passing the "To" Waypoint

ICAO RNAV Leg

Primary RNP Leg

## Constant Radius to a Fix



**RF** leg

Path - Arc About Reference Fix

Terminator - Terminating Fix

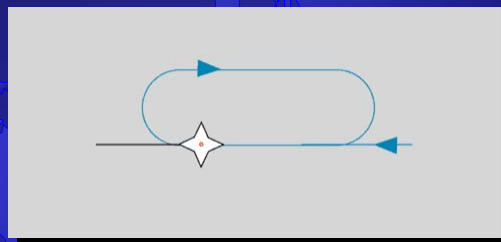
(all start and end fixes for RF legs are fly-by fixes)

(legs to and from RF leg “should” be tangent)

ICAO RNAV Leg

Primary RNP Leg

## Hold to a Manual Termination



**HM** leg

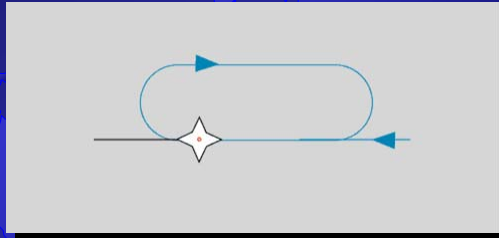
Path - Holding Pattern

Terminator - Manual Termination

ICAO RNAV Leg

Primary RNP Leg

## Hold to an Altitude



**HA** leg

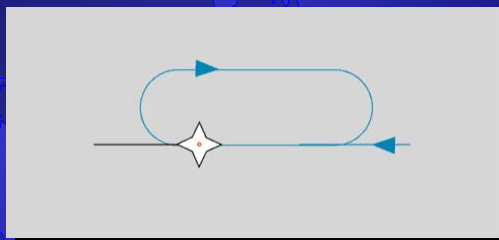
Path - Holding Pattern

Terminator - Terminating Altitude  
(Climb in the Holding Pattern)

ICAO RNAV Leg

Primary RNP Leg

## Hold to a Fix



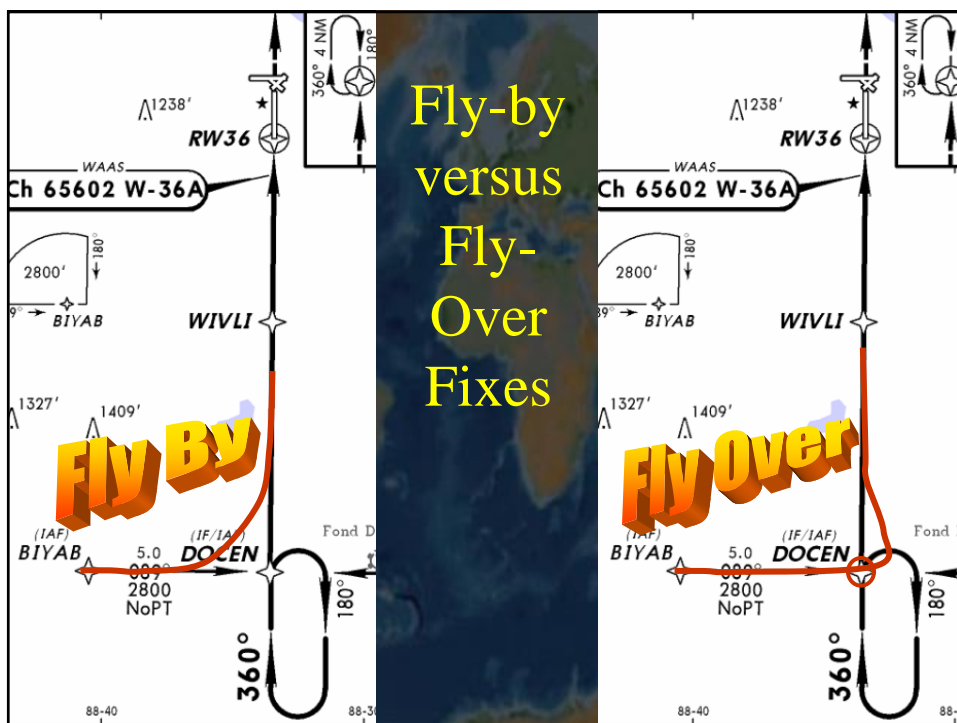
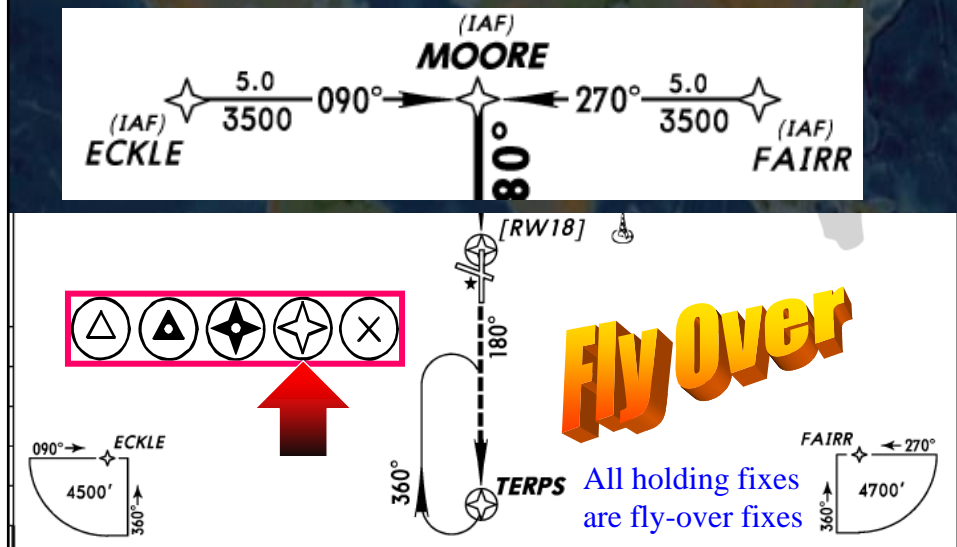
**HF** leg

Path - Holding Pattern

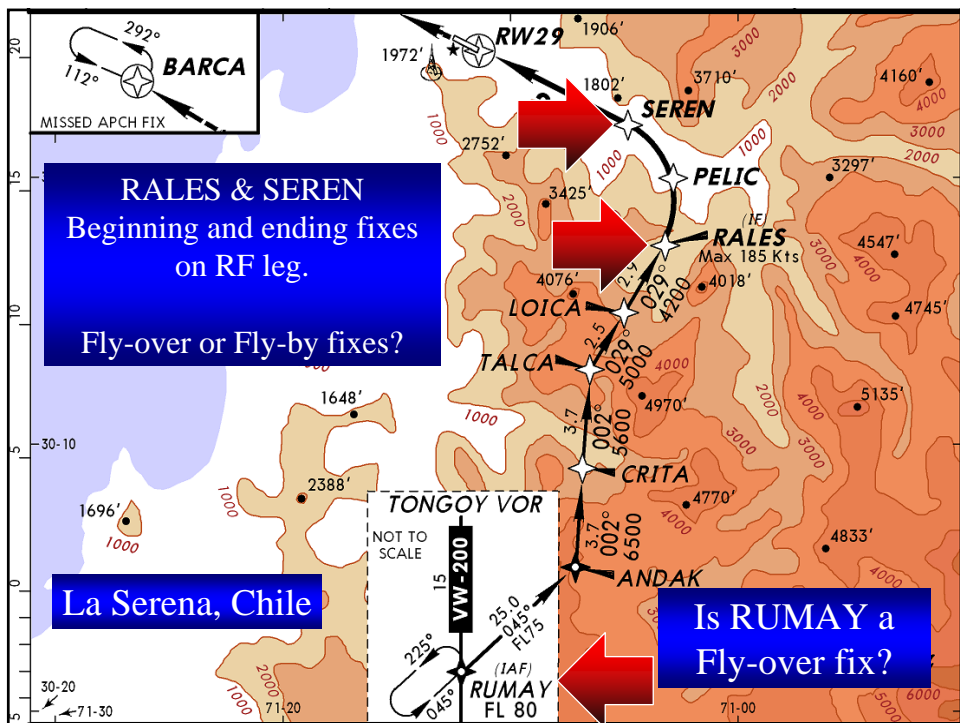
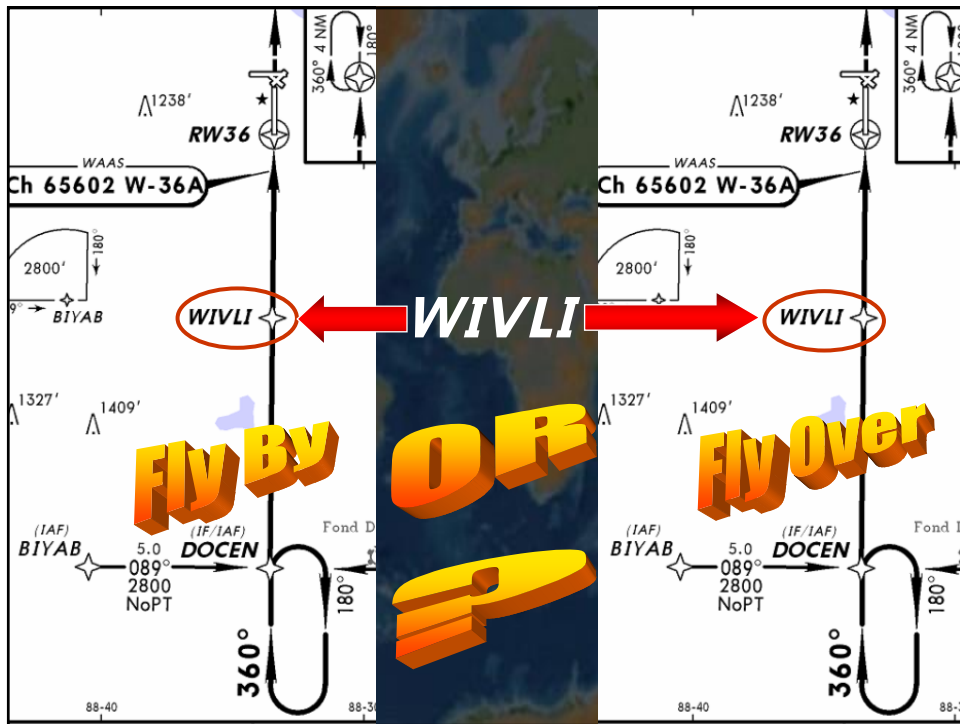
Terminator - 2nd Fix Crossing  
(One Circuit in the Hold)



## Fly-by Fix Symbol Standard







## State Requirements in PANS OPS

- Textual Description
  - ***Path and Terminator (“Path Terminator”).*** A two-letter code, which defines a specific type of flight path along a segment of a procedure and a specific type of termination of that flight path. Path terminators are assigned to all RNAV, SID, STAR and approach procedure segments in an airborne navigation database.
  - *Note.— Path terminators as defined in PANS-OPS are, with the exception of the RF path terminator, established in accordance with the rules set forth in ARINC Specification 424-15, Navigation System Data Base. The rules applicable to the RF path terminator are based upon ARINC 424-17.*

## Authorized Path Terminators

Table III-2-5-App-1. Initial and final path terminators

<i>RNAV procedure</i>	<i>Initial leg</i>	<i>Final leg</i>
SID	CA, CF, VA, VI	CF, DF, FM, HA, RF, TF, VM
STAR	IF	CF, DF, FM, HM, RF, TF, VM
Approach	IF	CF, TF, RF
Missed approach	CA, CF, DF, FA, HA, HM, RF, VI, VM	CF, DF, FM, HM, RF, TF, VM

# Path Terminator Sequences

Table III-2-5-App-2. Path terminator sequences

		Next Leg													
		IF	CA	CF	DF	FA	FM	HA	HF	HM	RF	TF	VA	VI	VM
Current Leg	CA														
	CF				1										
	DF				1										
	FA														
	FM														
	HA														
	HF														
	HM														
	IF					2	2	2	2	2	3				
	RF														
	TF														
	VA														
	VI														
	VM														

## Text Description ICAO PANS OPS Doc 8168

1.4.3 The textual or tabular description of the procedure to support navigation database coding shall incorporate all the data elements as specified in Chapter 2, and shall be published on the verso of the appropriate chart or as a separate properly referenced sheet (see Annex 4, 9.9.4.3, 10.9.4.3, and 11.10.9). In the following paragraphs three examples are provided (the formal, the abbreviated and the tabular description methods. The tabular description method is provided in Table III-5-1-2).

## Text Description ICAO PANS OPS Doc 8168

### 1.4.4 Formal description. In the formal description, the following principles apply:

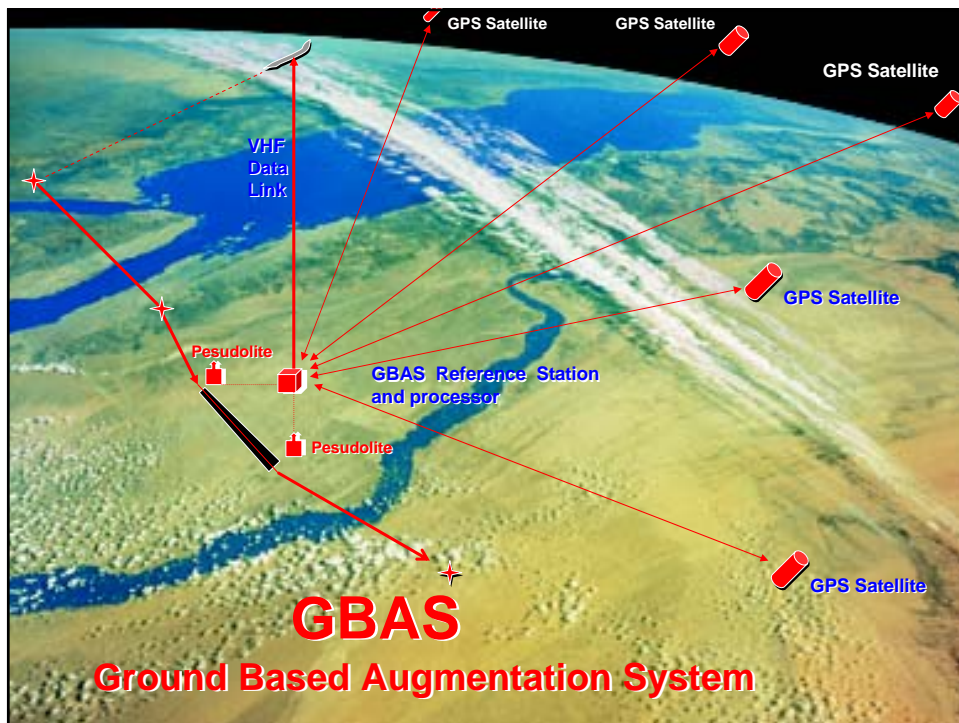
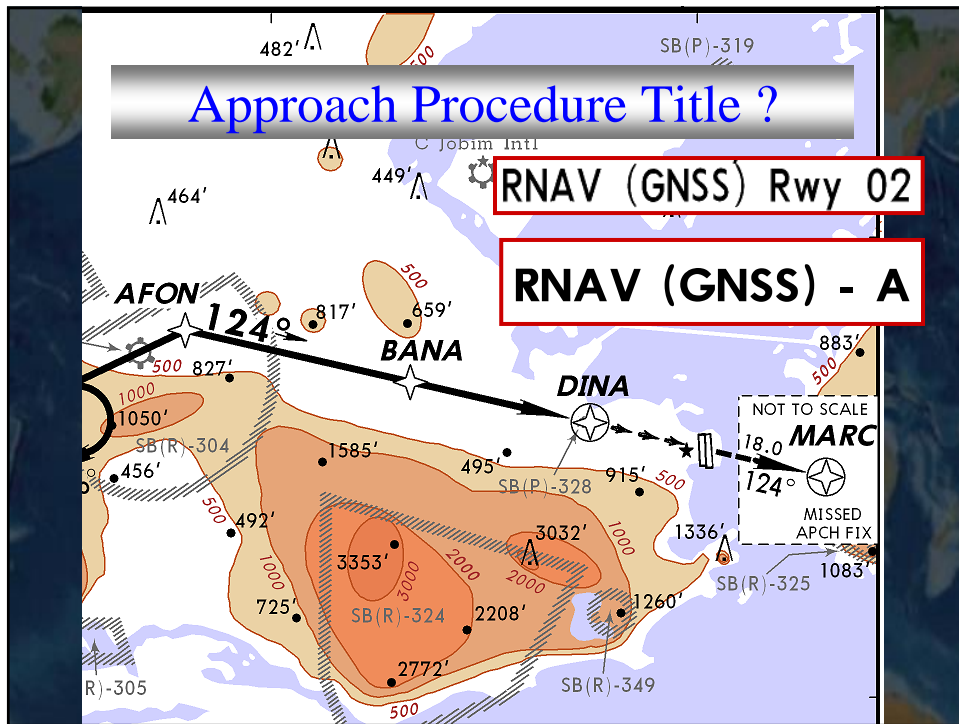
- (Waypoint) (underlined) denotes flyover.
- (Waypoint) (not underlined) denotes fly-by or RF waypoint as appropriate.
- To (Waypoint) denotes a TF path terminator.
- To (Waypoint) on course XXX° denotes a CF path terminator.
- Direct to (Waypoint) denotes a DF path terminator.
- (Waypoint) {R, NN.N, LatLong} denotes an RF path terminator, the radius and the centre point of a fixed radius turn in terminal airspace.
- Climb on track XXX°, at or above yyy feet turn right/left denotes a CA path terminator.
- From (Waypoint) to XXXX feet on track XXX° denotes an FA path terminator.
- Climb on heading XXX°, at or above yyy feet turn left/right denotes a VA path terminator.
- From (Waypoint) to XXXX feet on heading XXX° denotes a VA path terminator.
- Continue on heading XXX° denotes a VM path terminator.
- Continue on track XXX° denotes an FM path terminator.
- (Waypoint) {HM, Turn Direction, Inbound Track, Leg Distance/Time} denotes an HM path terminator.
- (Waypoint) {HA, Turn Direction, Inbound Track, Leg Distance/Time, Altitude} denotes an HA path terminator.
- (Waypoint) {HF, Turn Direction, Inbound Track, Leg Distance/Time} denotes an HF path terminator.
- The formal description method is illustrated in Table III-5-1-1.

## Approach Procedure Titles

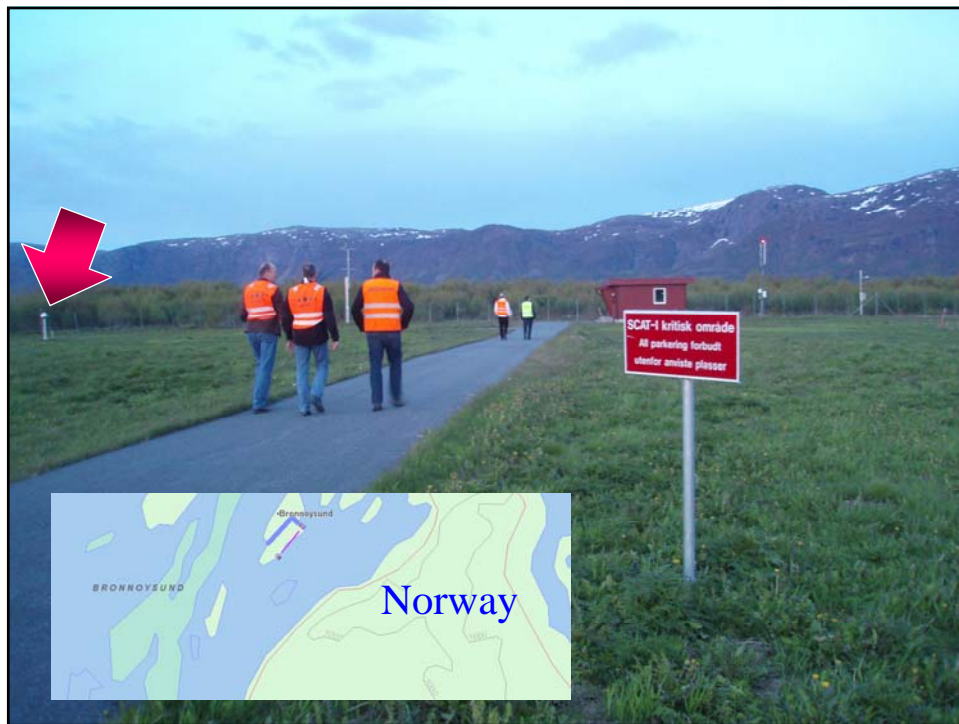
SCDA/IQQ		JEPPESEN		IQUIQUE, CHILE	
DIEGO ARACENA INTL		1 JUN 07 (12-1) Eff 7 Jun		RNAV (GNSS) Rwy 19	
IQUIQUE Approach (R)		IQUIQUE Tower		Ground	
122.7 124.9		118.9		121.7	
RN		<b>Straight-in Landing Runway</b>		8000'	
MISSED APCH: RIGHT turn direct PACIF 3500', enter holding pattern or according to ATC clearance.					
Alt Set: hPa Rwy Elev: 4 hPa Trans level: By ATC Trans alt: 6000'					
1. RADAR required. 2. CAUTION: 2829' mountain at 2.6 NM Northeast of VORTE.					
MSA KUMAT					

SCFM		JEPPESEN		PORVENIR, CHILE	
CAPITAN FUENTES MARTINEZ		20 JUL 01 (13-1)		VOR DME-A	
12		PORVENIR Information (AFIS)		126.7	
VOR NAS		Apch Crs		D17.0	
114.1		115°		1300' (1196')	
MISSED A		Refer to		Appt Elev 104'	
instruc		Minimums		4500'	
Alt Set: h				VOR	
		<b>No Straight-in Landing Runway</b>			

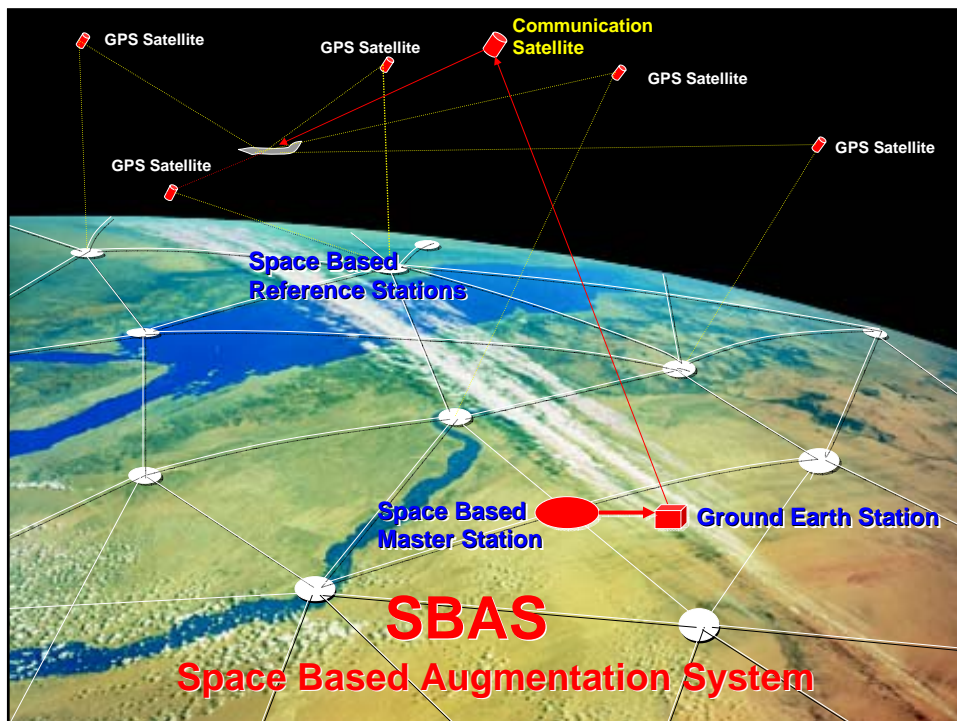




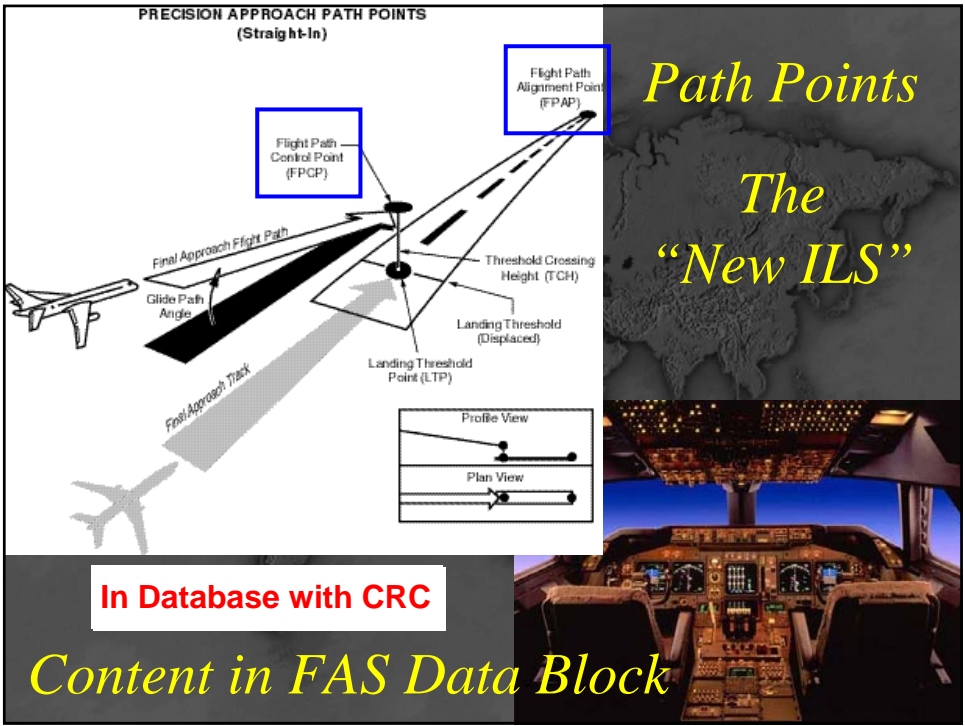
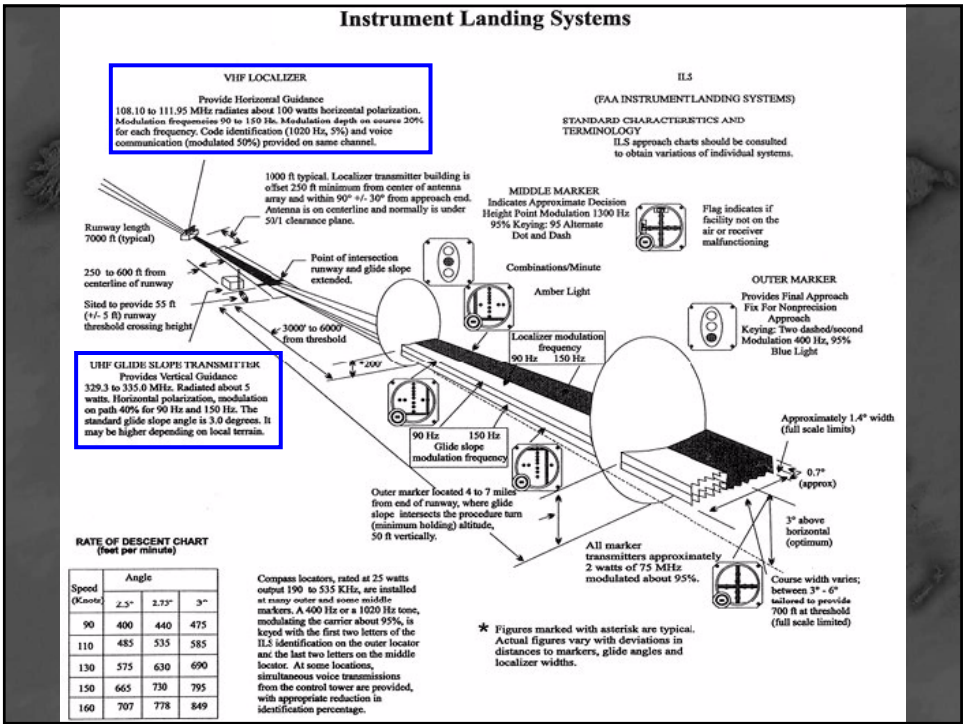












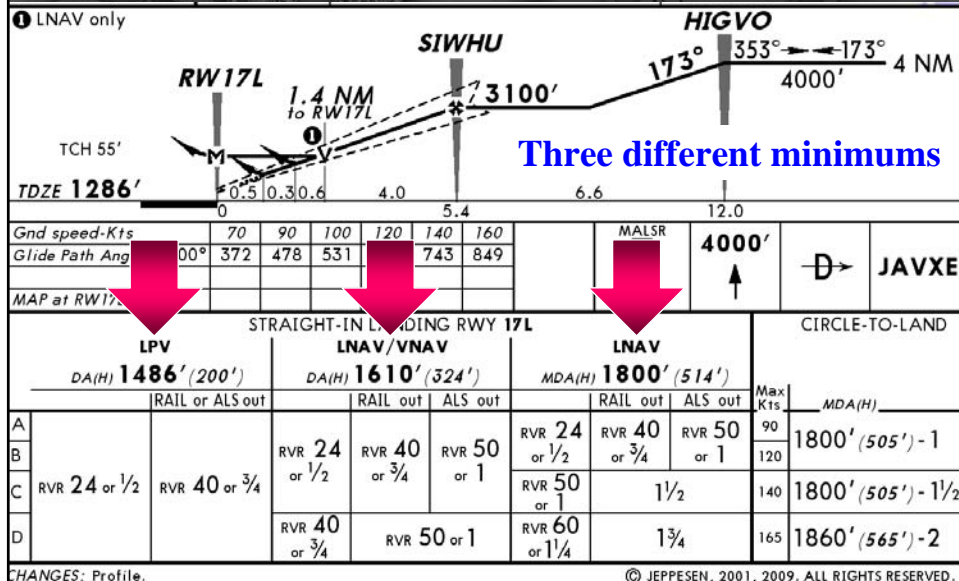
## Final Approach Segment FAS Data Block Record

Data Field	Field Size	Data Type
Operation Type	2 Characters	Unsigned Integer
SBAS Service Provider Identifier	2 Characters	Unsigned Integer
Aerodrome Identifier	4 Characters	Alphanumeric
Runway Identifier	5 Characters	Alphanumeric
Approach Performance Designator	1 Character	Unsigned Integer
Route Indicator	1 Character	Alpha
Reference Path Data Selector	2 Characters	Unsigned Integer
Reference Path Identifier	4 Characters	Alphanumeric
LTP Latitude	11 Characters	Alphanumeric
LTP Longitude	12 Characters	Alphanumeric
LTP Ellipsoidal Height	6 Characters	Signed Integer
FPAP Latitude	11 Characters	Alphanumeric
FPAP Longitude	12 Characters	Alphanumeric
Threshold Crossing Height	7 Characters	Alphanumeric
Glide Path Angle	4 Characters	Unsigned Integer
Course Width at Threshold	5 Characters	Unsigned Integer
Length Offset	4 Characters	Unsigned Integer

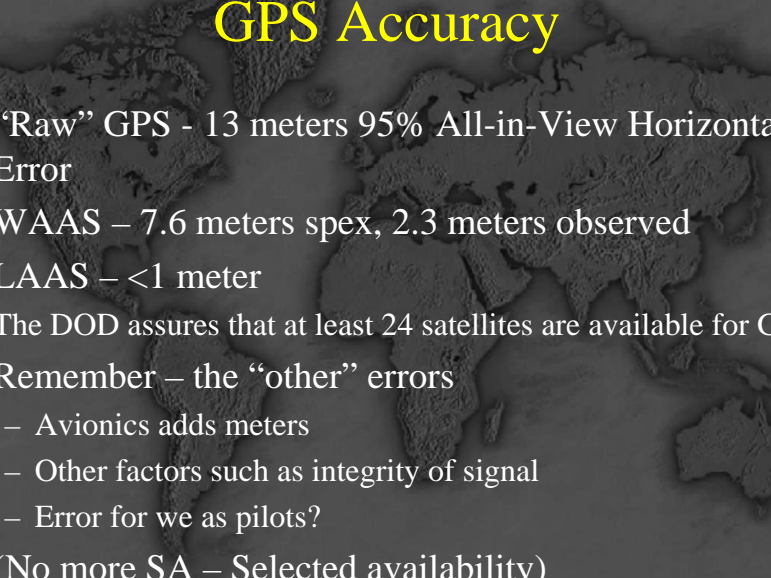


Limited SBAS

## SBAS Approach



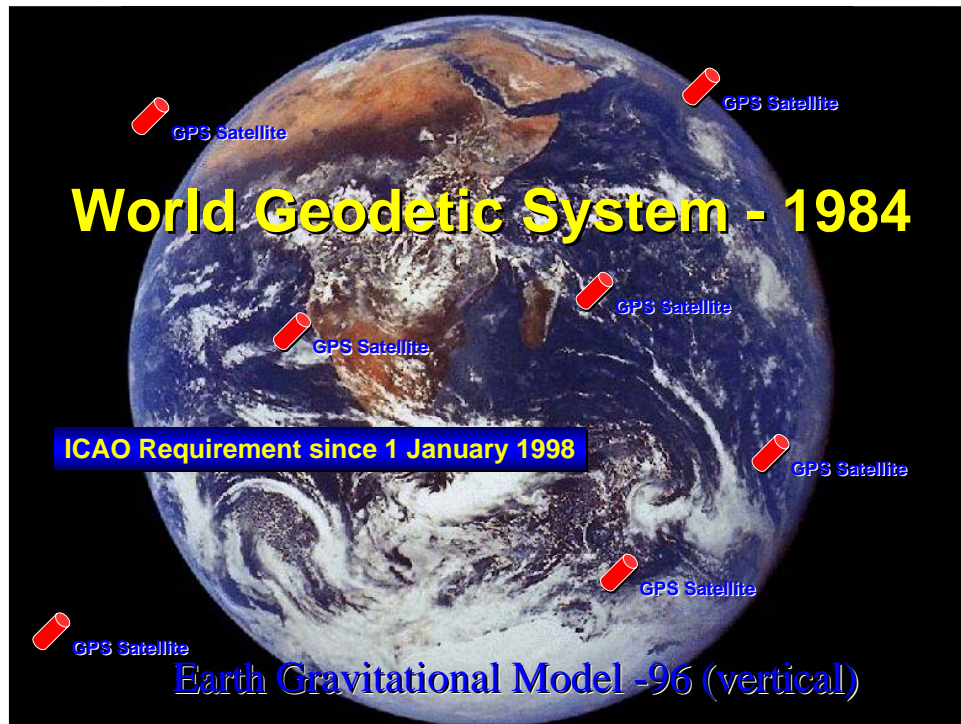




# GPS Accuracy

- “Raw” GPS - 13 meters 95% All-in-View Horizontal Error
- WAAS – 7.6 meters spex, 2.3 meters observed
- LAAS – <1 meter
- The DOD assures that at least 24 satellites are available for GPS
- Remember – the “other” errors
  - Avionics adds meters
  - Other factors such as integrity of signal
  - Error for we as pilots?
- (No more SA – Selected availability)



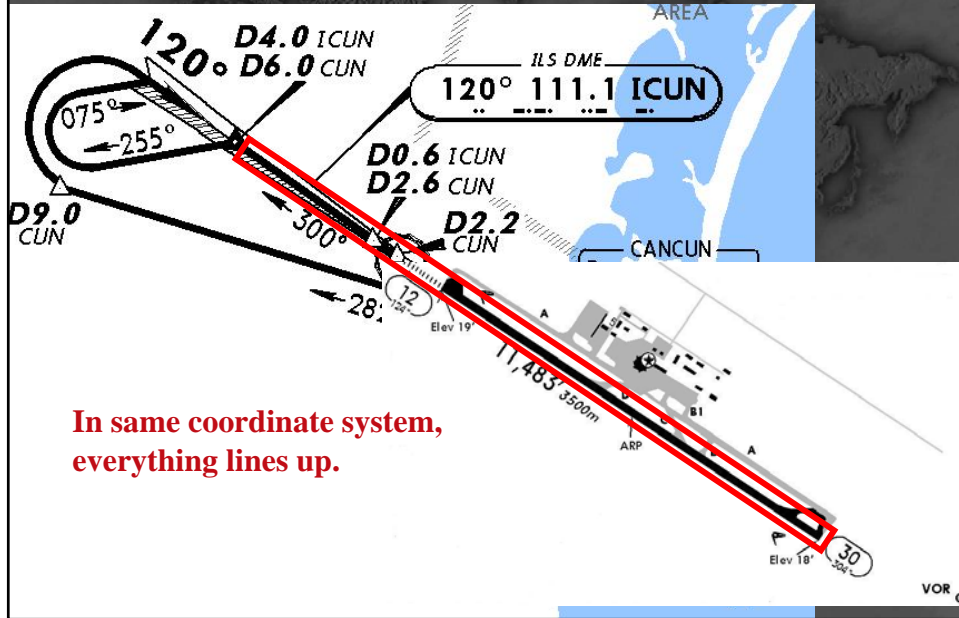


## WGS-84

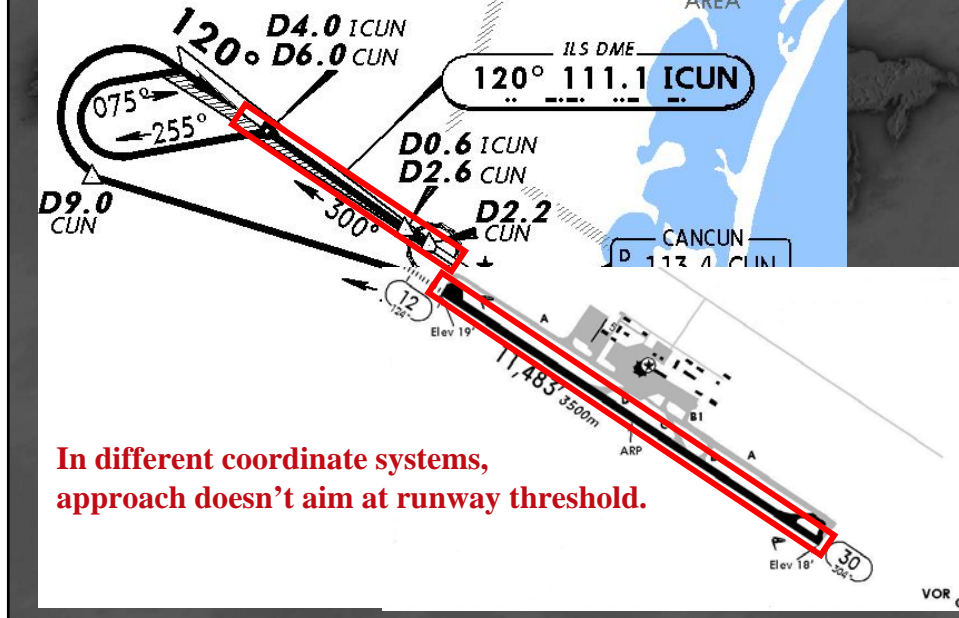
### “Errors”

- An airline captain reports: “My FMS shows I’m over the Pachuca VOR but I can see it out the window off to my left.”
- Does the database have an error?”

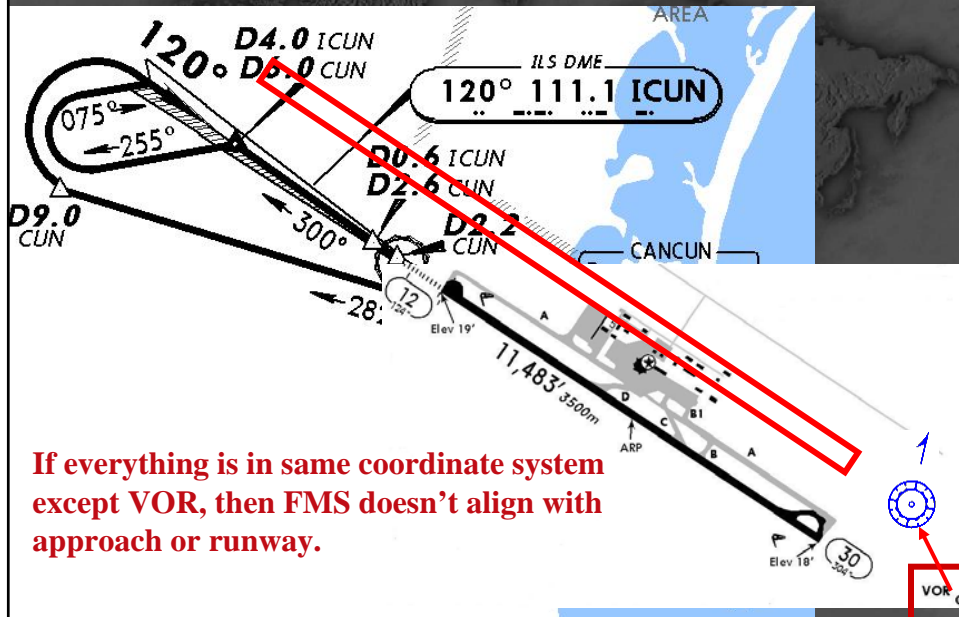
## Mismatch of Coordinate Datums



## Mismatch of Coordinate Datums



## Mismatch of Coordinate Datums



## WGS - 84 Status

129 States converted to WGS-84 as of March 2009

WGS-84 Status Report			(As of March 2009)		
Afghanistan - C	Albania - C	Algeria - C	Ethiopia - C	Faroe Is. - C	Fiji Is. - C
Angola - C	Argentina - C	Armenia - C	Finland - C	France - C	France (MIL) - C
Aruba - C	Ascension I. - C	Australia - C	French CAR/SAM/NAM - C	French Guiana - C	French Pacific Ter. (PAC-N) - C
Austria - C	Azerbaijan - PC	Azores (Portugal) - C	French Pacific Ter. (PAC-P) - C	Gabon - C	Gambia - C
Bahamas - C	Bahrain - C	Bangladesh - C	Gaza - C	Georgia - C	Germany - C
Barbados - C	Belarus - U	Belgium - C	Germany (MIL) - C	Ghana - C	Gibraltar - C
Belgium (MIL) - C	Belize - U	Benin - C	Greece - U	Greenland - PC	Guatemala - C
Bermuda - C	Bhutan - U	Bolivia - C	Guinea Bissau - U	Guinea Rep. - C	Guyana - C
Bosnia-Herzegovina - C	Botswana - C	Brazil - C	Haiti - C	Honduras - NC	Hong Kong - C
Brunei - U	Bulgaria - C	Burkina Faso - C	Hungary - C	Iceland - C	India - C
Burundi - C	Cambodia - C	Cameroon - C	Indonesia - C	Iran - C	Iraq - C
Canada - C	Canary Islands - C	Cape Verde - C	Ireland - C	Israel - PC	Italy - PC
Cayman Islands - C	Central African Republic - C	Chad - C	Ivory Coast - C	Jamaica - C	Japan - C
Chagos Archipelago - C	Chile - C	China, P.R. of - U	Jerusalem - PC	Jordan - C	Kazakhstan - PC
Colombia - C	Comoros - C	Congo D.R. of - U	Kenya - PC	Kiribati - U	Korea D.P.R. of - PC
Congo, Rep. of - C	Costa Rica - C	Croatia - C	Kuwait - C	Kyrgyzstan - U	Laos - U
Cuba - C	Cyprus - C	Czech - C	Latvia - C	Lebanon - C	Lesotho - U
Dakhla/Laayoune - C	Denmark - C	Denmark (MIL) - C	Liberia (Roberts FIR) - C	Libya, SPLAJ - U	Lithuania - C
Djibouti - C	Dominican Republic - C	Eastern Caribbean Is. - C	Luxembourg - C	Macao, P.R. of China - C	Macedonia F.Y.R. of - C
Ecuador - C	Egypt - C	El Salvador - C	Madagascar - C	Madeira Is. - C	Malawi - PC
			Malaysia - C	Maldives - C	Mali - C
			Malta - C	Mauritania - C	Mauritius - C
			Mayotte - C	Melilla (Spain) - C	Mexico - C



# WGS - 84 Status

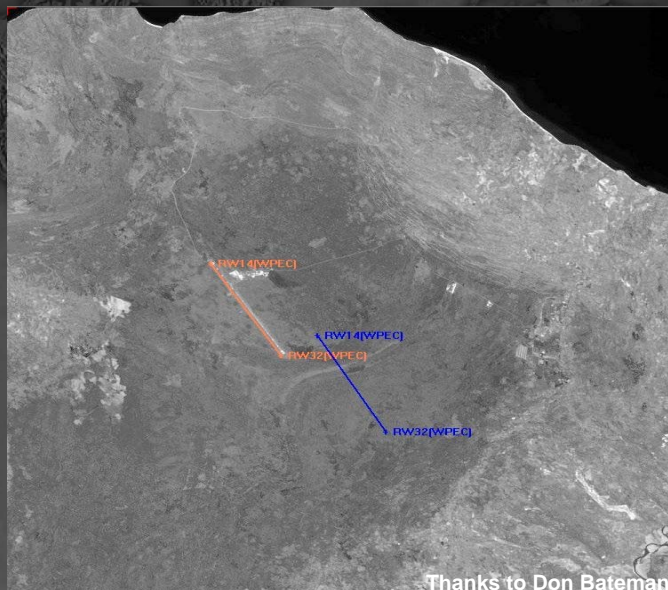
129 States converted to WGS-84 as of March 2009

**All of South America is WGS-84 compliant**

Many States have partially implemented WGS-84, Some are non-compliant and others unknown because lack of statement in AIP

Mayotte - C	Melilla (Spain) - C	Mexico - C
Moldova - C	Monaco (France) - C	Mongolia - PC
Morocco - C	Mozambique - U	Myanmar - C
Namibia - C	Nauru - U	Nepal - C
Netherlands - C	Netherlands (MIL) - C	Netherlands Antilles - U
New Zealand - C	Nicaragua - NC	Niger - C
Nigeria - C	Norway - C	Oman - C
Pakistan - C	Panama - C	Papua New Guinea - U
Paraguay - C	Peru - C	Philippines - C
Poland - C	Portugal - C	Portugal (MIL) - C
Pristina - C	Qatar - C	Reunion - C
Romania - C	Russia - U	Rwanda - C
Samoa - C	Sao Tome & Principe - C	Saudi Arabia - C
Saudi Arabia - C	Senegal - C	Serbia and Montenegro - C
Seychelles - C	Sierra Leone - C	Singapore - C
Slovakia - C	Slovenia - C	Solomon Is. - C
Somalia - U	South Afr. Rep. - C	South Korea, Rep. of - C
Spain - C	Sri Lanka - C	Sudan - C
Suriname - C	Swaziland - NC	Sweden - C
Sweden (MIL) - C	Switzerland - C	Syria - U
Taiwan - C	Tajikistan - U	Tanzania - C
Thailand - C	Timor Leste - U	Togo - C
Tonga - C	Tunisia - C	Turk. Rep. of N. Cyprus - C
Turkey - C	Turkmenistan - U	Turks and Caicos Is. - C
Uganda - C	Ukraine - U	United Arab Emirates - C
United Kingdom - C	United Kingdom (MIL) - C	United States - C
Uruguay - C	US Caribbean Territories - U	US Pacific Territories - U
Uzbekistan - U	Vanuatu - C	Venezuela - C
Vietnam - C	Yemen - C	Zambia - U
Zimbabwe - PC		

## Satellite Picture of Actual Runway Location (orange) versus Official AIP Location (blue)

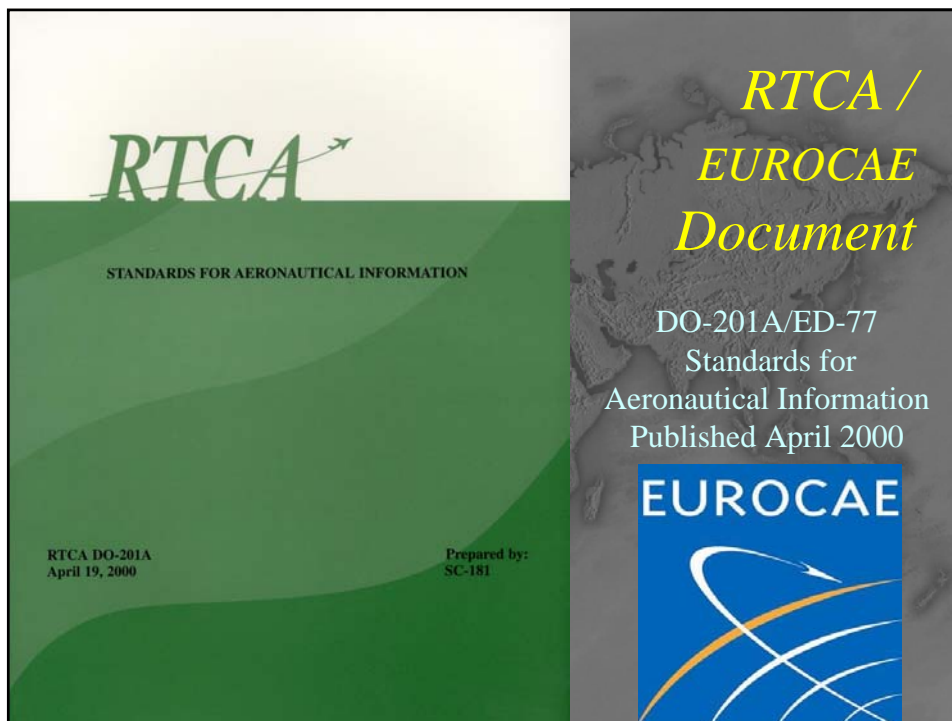
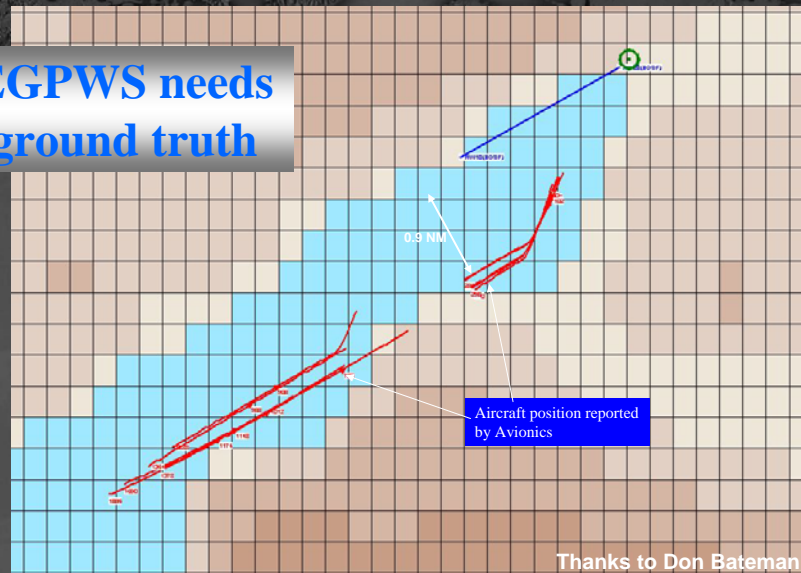


Thanks to Don Bateman



## An example of Unwanted Warnings caused by Avionics not aligned with ground truth

EGPWS needs  
ground truth



## APPENDIX 7. AERONAUTICAL DATA QUALITY REQUIREMENTS

Table A7-1. Latitude and longitude

Latitude and longitude	Publication resolution	Integrity Classification
Flight information region boundary points	1 min	$1 \times 10^{-3}$ routine
P, R, D area boundary points (outside CTA/CTZ boundaries)	1 min	$1 \times 10^{-3}$ routine
P, R, D area boundary points (inside CTA/CTZ boundaries)	1 sec	$1 \times 10^{-3}$ essential
CTA/CTZ boundary points	1 sec	$1 \times 10^{-3}$
En-route NAVAIDS and fixes, holding, STAR/SID points		
Obstacles in Area 1 (the entire State territory)		
Aerodrome/heliport reference point		
NAVAIDS located at the aerodrome/heliport		
Obstacles in Area 3		
Obstacles in Area 2		
Final approach fixes/points and other essential fixes/points complete instrument approach procedure		
Runway threshold		
Runway end (flight path alignment point)		
Runway holding position		
Taxiway centre line/parking guidance line points	1/100 sec	$1 \times 10^{-3}$ essential
Taxiway intersection marking line	1/100 sec	
Exit guidance line	1/100 sec	
Aircraft stand points/DNS checkpoints	1/100 sec	
Geometric centre of TLOF or FATO thresholds, heliports	1/100 sec	
Apron boundaries (polygon)	1/10 sec	
De-icing/anti-icing facility (polygon)	1/10 sec	

Note.— See Appendix 8 for graphical illustrations of obstacle data collection surfaces and criteria used in the defined areas.

ANNEX 15

APP 7-1

28/11/04

## Annex 15

Appendix 7 Includes:

- A7-1 Latitude/Longitude
- A7-2 Elevation/Altitude/Height
- A7-3 Declination & Magnetic Variation\*
- A7-4 Bearing
- A7-5 Length/Bearing/Dimension

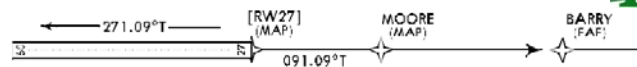
Three Factors:

- Accuracy
- Resolution (chart vs. database)
- Integrity

### D.4.2 Calculation of Final Approach Fix (FAF) Coordinates -

**Example 1** - Where the FAF (BARRY) is on the runway centerline extended, use the reciprocal of the landing runway true bearing, threshold coordinates, and the intended distance from the threshold to the FAF for calculating the coordinates. The MAP may or may not be located at the threshold.

**Note:** Industry specifications do not require the application of a name to a MAP located at the threshold or runway end.



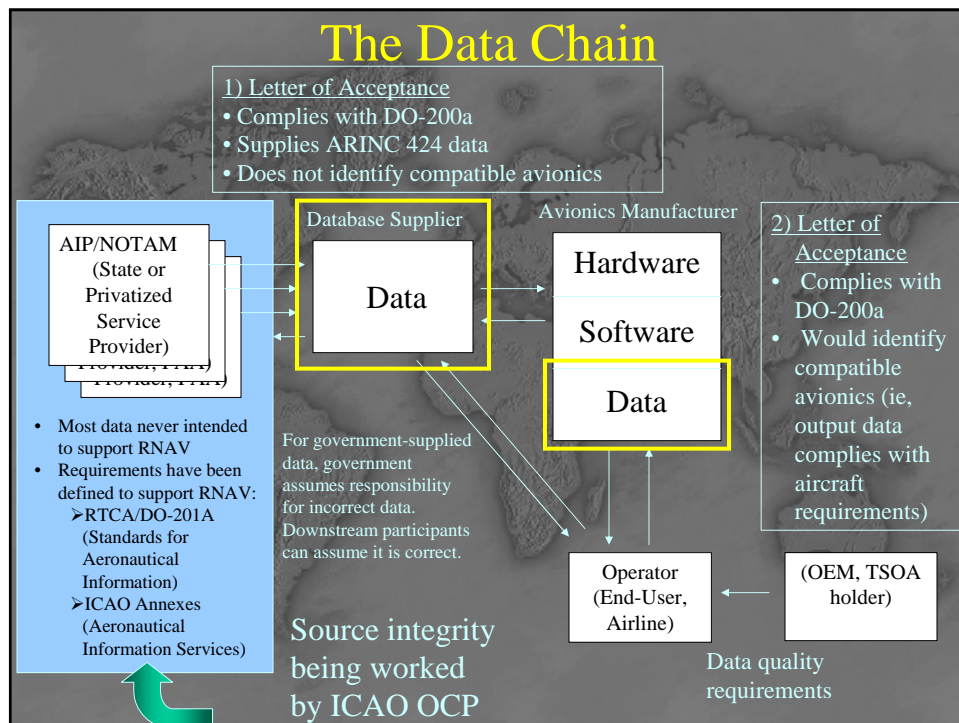
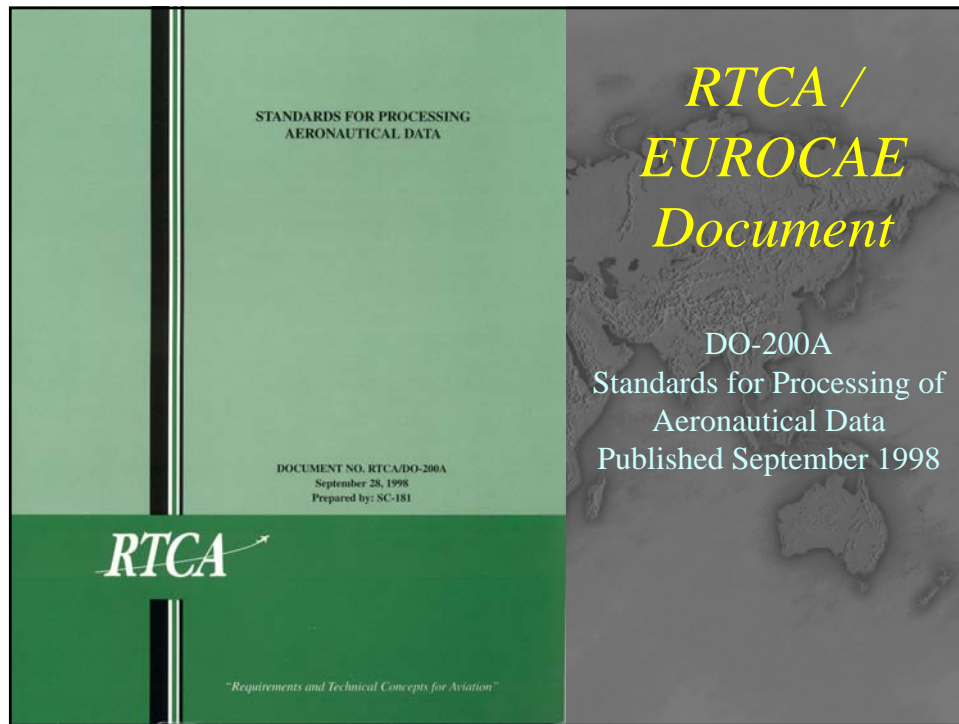
**Example 2** - Where a continuous geodesic track includes the FAF, the MAP, and the threshold but does not lie on the runway centerline extended, calculate the FAF (MASON) coordinates using the threshold coordinates and the true bearing and distance from the threshold.

**Note:** Use the same true bearing to create both the MAP and the FAF coordinates. The MAP may or may not be located at the threshold. Industry specifications do not require the application of a name to a MAP located at the threshold or runway end.

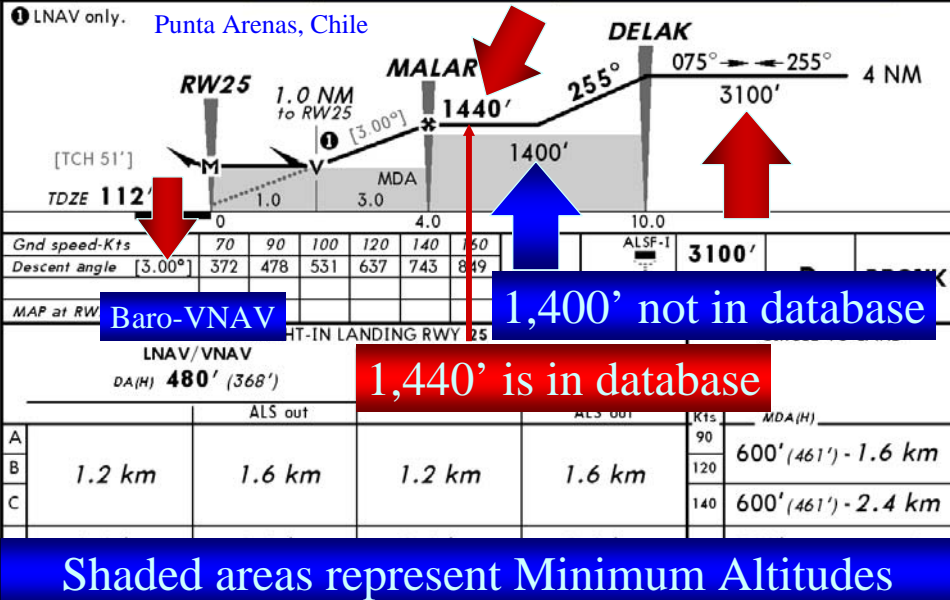


Will be included in ICAO Construction Manual

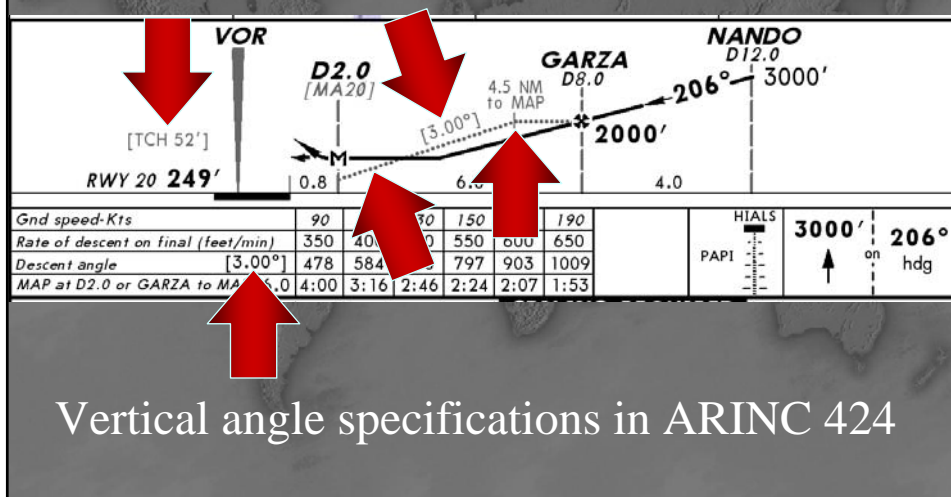
MASON  
(FAF)



## Procedure Altitudes

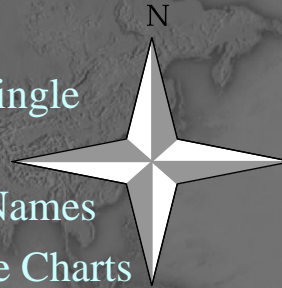


## Descent Angles on Conventional Procedures

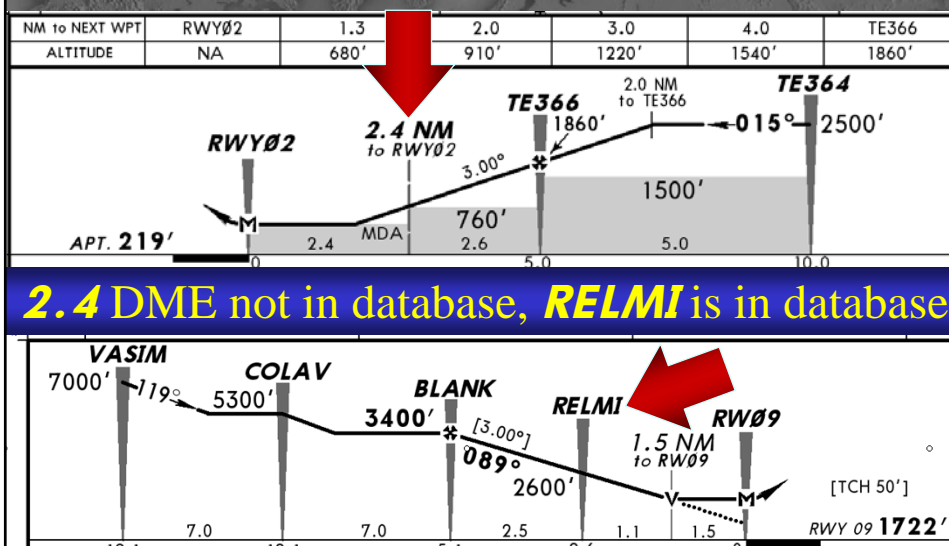


## Large Issue - Waypoint Names

- Common Waypoint Name for Single Location
- DME Fixes without Waypoint Names
- Unnamed Waypoints on Enroute Charts
- Unnamed Stepdown Fixes
- FACF Waypoint Unnamed
- Five-letter Names & Identifiers for NDBs



## Naming Stepdown Fixes





# Chart & Database Compatibility

San Jose Del Cabo, Mexico approach



## Effective Dates

- ICAO AIRAC Cycles
- Lack of Lead Time by State Sources
- Cut-off Date on Charts different than Data

SBBH/PLU

PAMPULHA-CARLOS

DRUMMOND DE ANDRADE

JEPPESSEN

BELO HORIZONTE, BRAZIL

18 SEP 09

11-1

Eff 24 Sep

ATA, B & C

LOC DME Rwy 13

ATIS		BELO HORIZONTE Control (R) (APP)				BELO HORIZONTE Tower		Ground	
127.45		119.65	120.2	129.1	129.	118.0		121.6	
LOC IPM	Final Apch Crs	Minimum Alt POPRI		MDA(H)		Apt Elev 2589'			
109.3	133°	4220' (1639')		3210' (629')		Rwy 13 2581'			
MISSED APCH: Climb to 4500' on 133° heading, then climbing RIGHT turn to 6000' to LUVGA and hold.									
Alt Set: hPa		Rwy Elev: 91 hPa		Trans level: By ATC		Trans alt: 6000'			

BRIEFING STRIP

180°

FL 80

270°

FL 100

360°

FL 75

090°

FL 70

MSA BHZ VOR

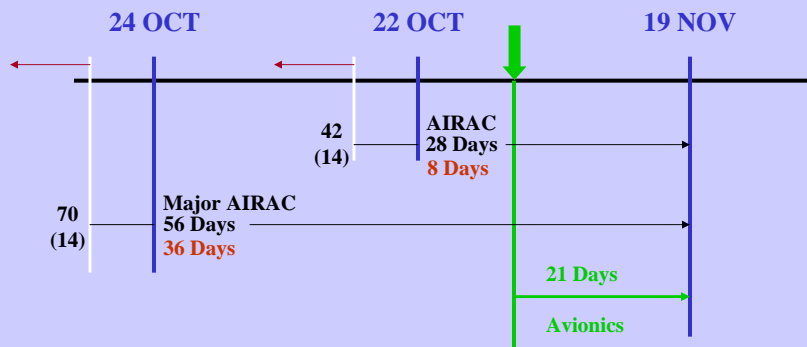
## States are obligated to publish Aeronautical Information According to ICAO Annex 15 and ICAO Doc 8126

AIRAC Type Changes - To Recipient 28 Days Before Effective Date,  
Mail 42 Days in Advance.

Major Changes - To Recipient 56 Days Before Effective Date,  
Mail 70 Days in Advance.

**DATE RAW DATA RECEIVED BY AIS (State)**  
**PUBLICATION DATE (ICAO)**  
**EFFECTIVE DATE (ICAO)**  
**DATABASE PROCESSING TIME (Avionics)**  
**DATA PREPARATION TIME (Database Supplier)**

### Significant Dates



**SABE/AEP**  
**JORGE NEWBERY**  
**AEROPARQUE**

**JEPPESSEN BUENOS AIRES, ARGENTINA**

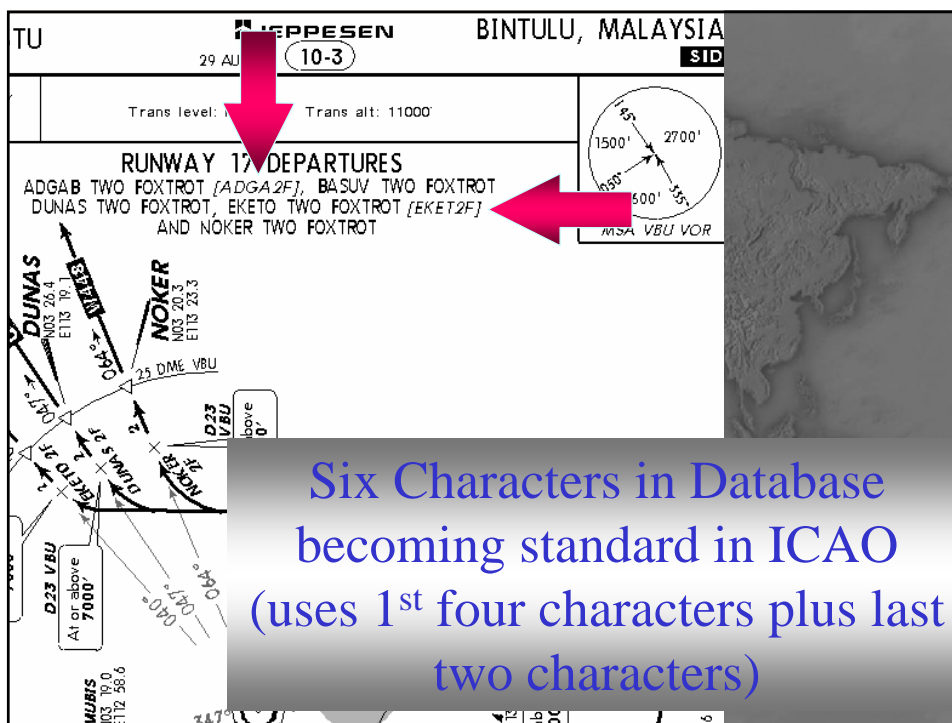
07 AUG 09 **(40-2A)**

**STAR**

*ATIS <b>127.6</b>	Apt Elev 18'	Alt Set: hPa Trans level: By ATC    Trans alt: 3000'	3000'
<p style="text-align: center;"> <b>BELGRANO7C (GBE7C), KOVUK7C,            SARGO7C, SURBO7A, TENIL7C ARRIVALS</b>            (RWY 13)         </p> <p style="text-align: center;"> <b><u>SPEED:</u> MAX 250 KT BELOW FL 100</b> </p>			<p style="text-align: center;"> <b>ICAO</b>  <b>KOVU7C</b>  <b>SARG7C</b>  <b>SURB7A</b>  <b>TENI7C</b> </p>

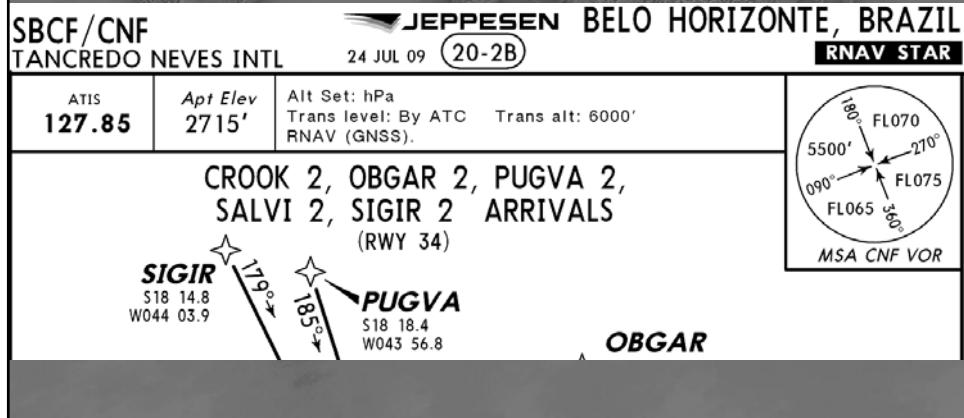
**ARINC 424 handles only 6 characters**

**ICAO uses 1st four characters plus last two characters for Ident**



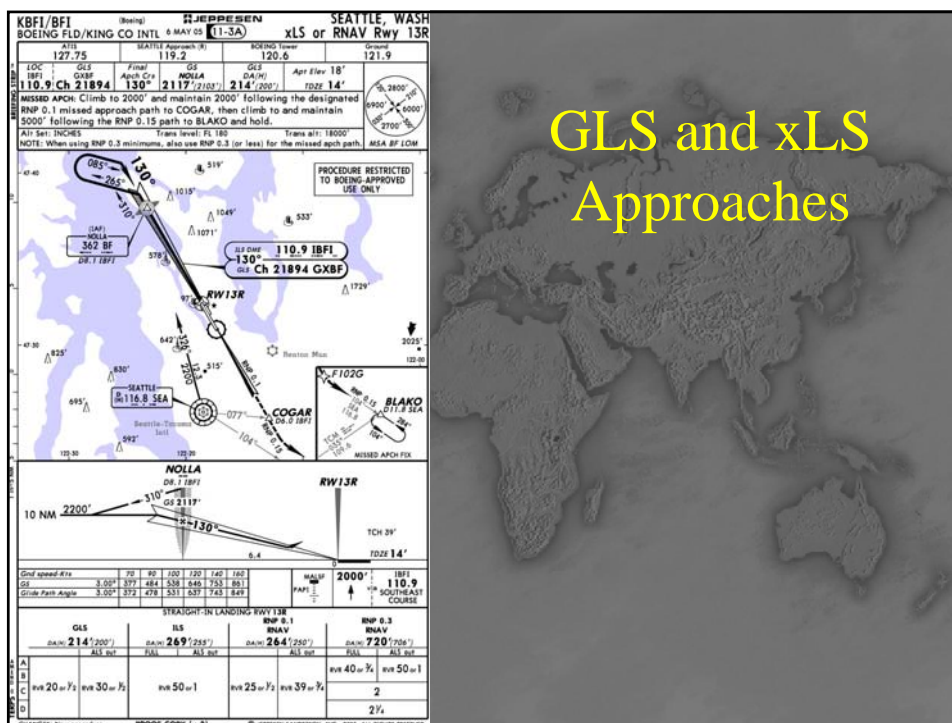
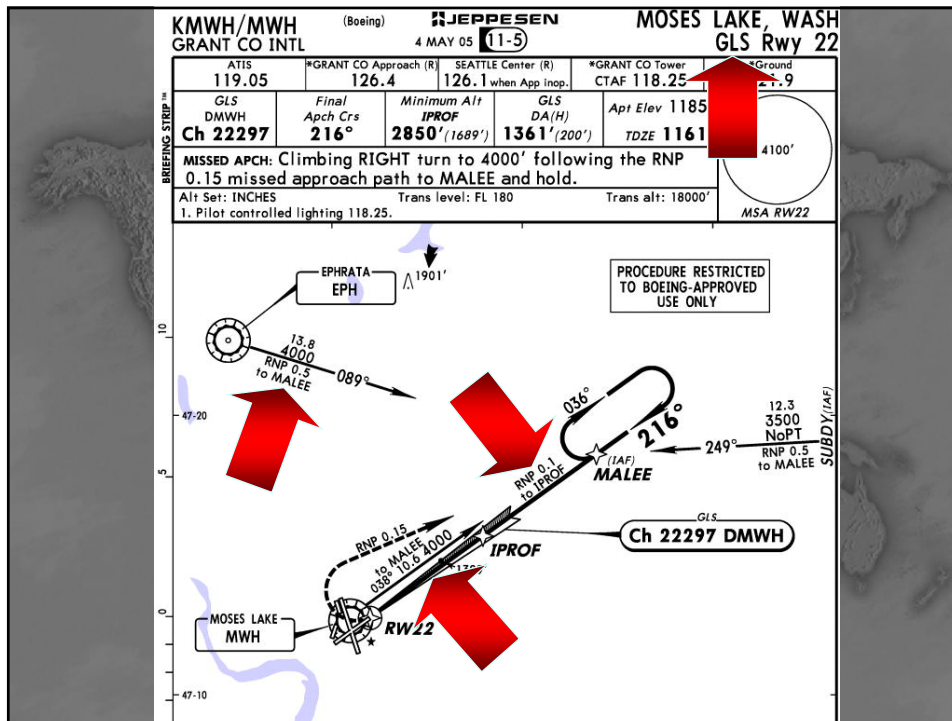
## SID & STAR Identifiers

When the ID is five letters plus a revision number, that becomes the database identifier



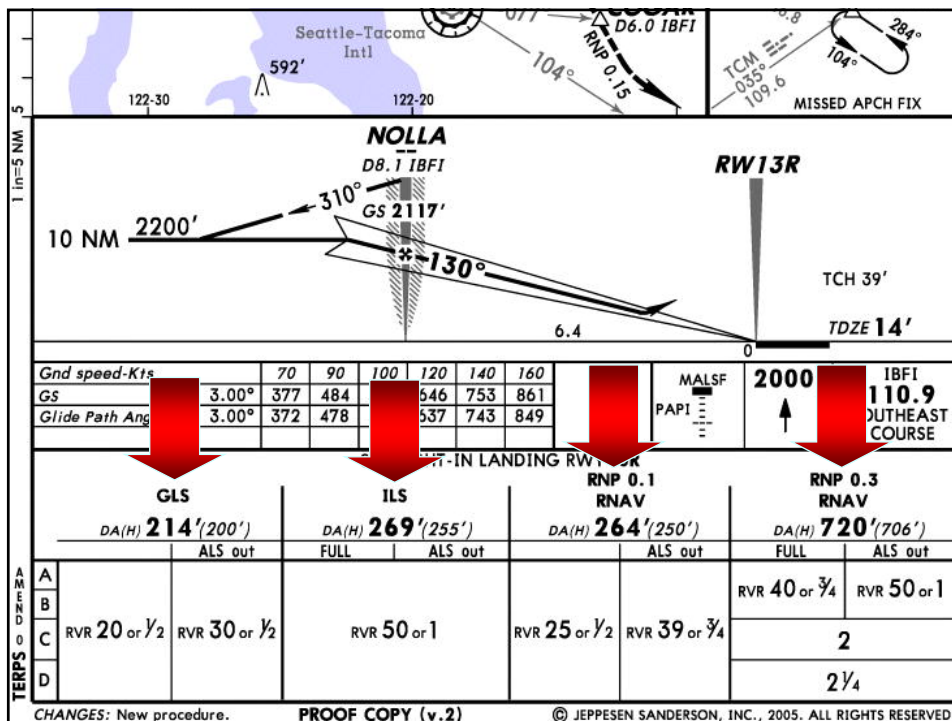
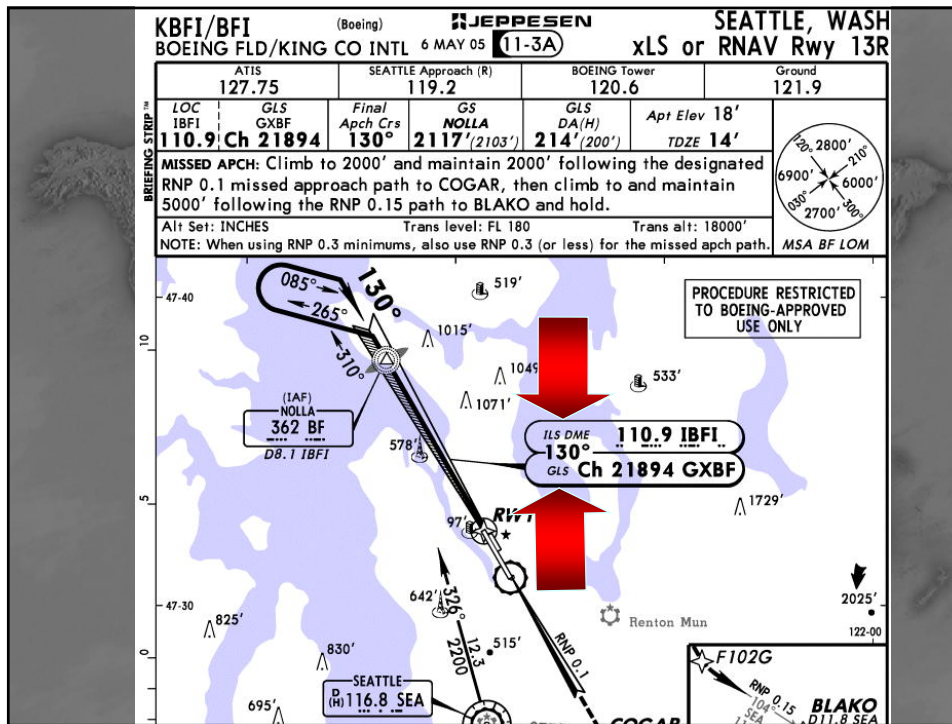
## PRECISION GPS APPROACHES

- Precision approaches
- Non-precision approaches
- Non-precision approaches with vertical (APV)



## GLS and xLS Approaches







But -  
Who wants to go back  
to the old?

# RNAV (GNSS) Procedures and ARINC 424

Lima, Peru **ICAO South American Region  
Implementation Group**  
19 October 2009

Jim Terpstra

