

**UPDATE On
GNSS
Aviation
Operations In
Australia**



GPS

- Excellent and improving service
 - Thank you USAF!!!
- Since 1995 no system issues
 - Primary Means GPS in 1995
- Issues
 - SPS – please update to real performance!
 - Some minor NANU Errors
 - Leads to RAIM prediction errors
- Some States still have concerns with GPS
 - Lack of Knowledge of ICAO (GPS) Status
 - More education needed

BASIC GNSS OFFERS MANY BENEFITS

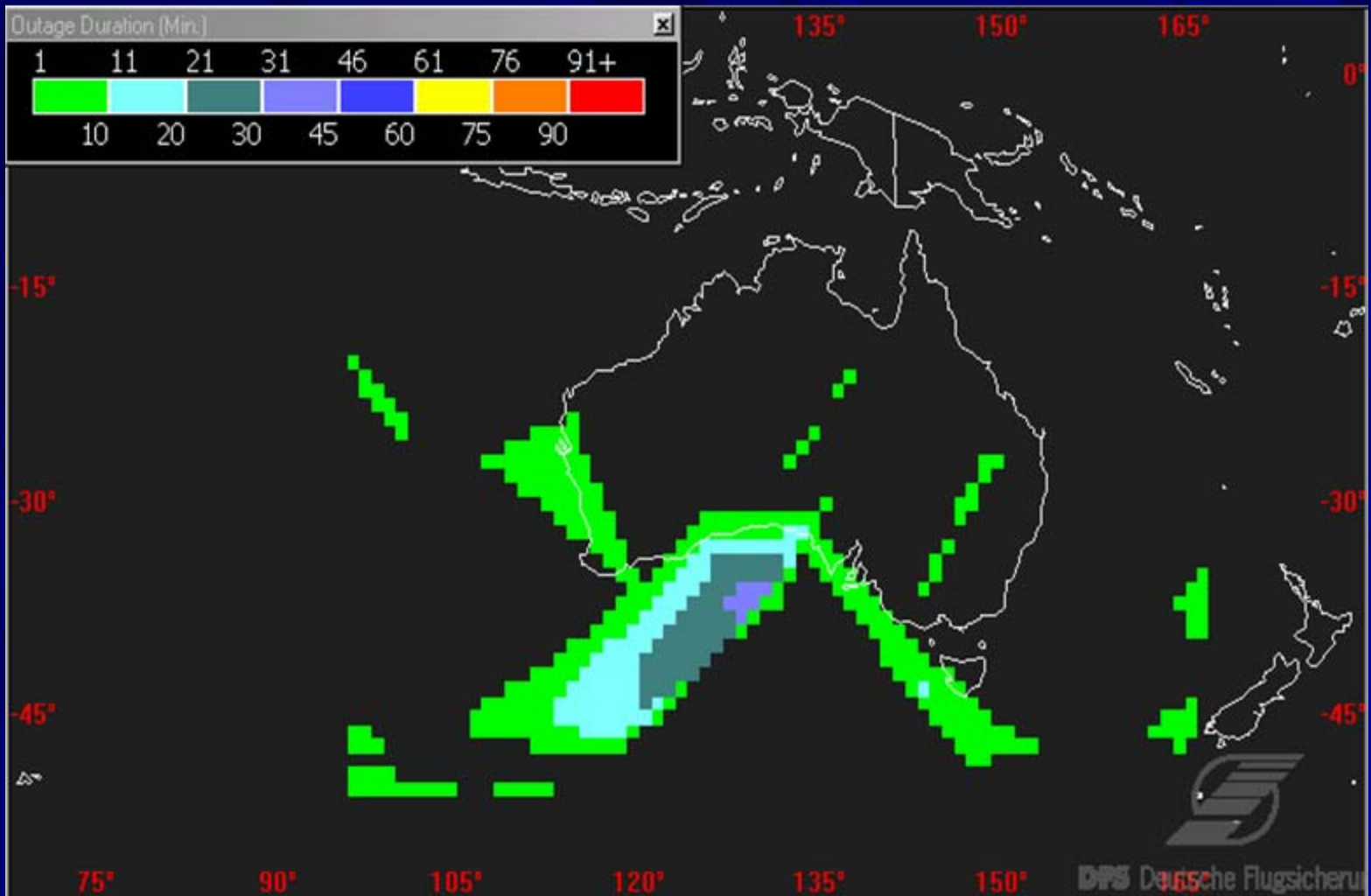
Standards in Place

Cheap and simple

Disaster immune

Little Implementation in Region

Why?



Very high user expectations due to excellent performance
Reduction to SPS level would totally undermine user confidence
GPS Constellation Management Critical

australia



photo: michalturski.com

Background

- Early decision – 1991
 - Lack of ground based infrastructure
 - Move to user pays funded system
 - No Government support other than for regulation
- Acceptance of US TSO C129 receiver
- Move to GNSS navigation
 - 85% of all operations now use GPS
 - Approvals range from NVFR to RNP-AR

HISTORY 2

- ICAO GNSS Panel formed in 1994
 - ICAO Circular 267
 - Basis for ICAO GNSS Manual in 2003
- 2003 Navigation Systems Panel
- 2003 ANC -11 = GNSS Transition OK
- ICAO GNSS Manual - Doc 9849
- Doc 8071 – Flight Inspection & Validation
- PBN Manual in 2007

GNSS Receivers

QUIT

MENU

ENTER

GPSmap 76

MARK

SPEED

0.0^k

ELEVATION

2079'

ACCURACY

0.1'

3D Differential



12-MAR-06 07:37:40

S 35°21.954'
E 149°06.359'

GARMIN

FIRST IFR GPS RECEIVER



Still 10,000+ in operation

TSO C146 Receivers



Includes VHF, VHF NAV and GPS

Garmin Simulators - free download

TSO C145/6

- Fault Detection and Exclusion (FDE)
- Selective Availability OFF
- Advanced RAIM
- Better Interference Protection
- Better Human Factors
- SBAS Capable (but not required)
- Available Training Aids (CD)
- Primary Means Design

RECEIVER DESIGNS

- ICAO – new approvals should be C145/6 based
- MMRs – multi mode receivers
 - Now the GNSS Sensor in Modern Airliners
 - IATA – “No SBAS in our aircraft”
 - WHY???!!!!!
- Galileo/GPS Hybrid Receivers expected

WAAS Satellite



APOLLO CNX80

COM

ACT 124.500

SBY 118.700

VOR

ACT 116.70

16.7m vor

SBY 109.50

XPDR

UTC 22:09:44

CDI

VOR 145



23
134
20
16
1
24
11
30
22
14
25

WAAS: Standby

TIME: 22:09:44

EPU: 0.02 nm

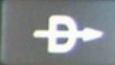
HPL: 41 m VPL: ---

35°32.31'S 149°19.51'E

SYS

GPS VERS CNFG

MAP



NRST

INFO

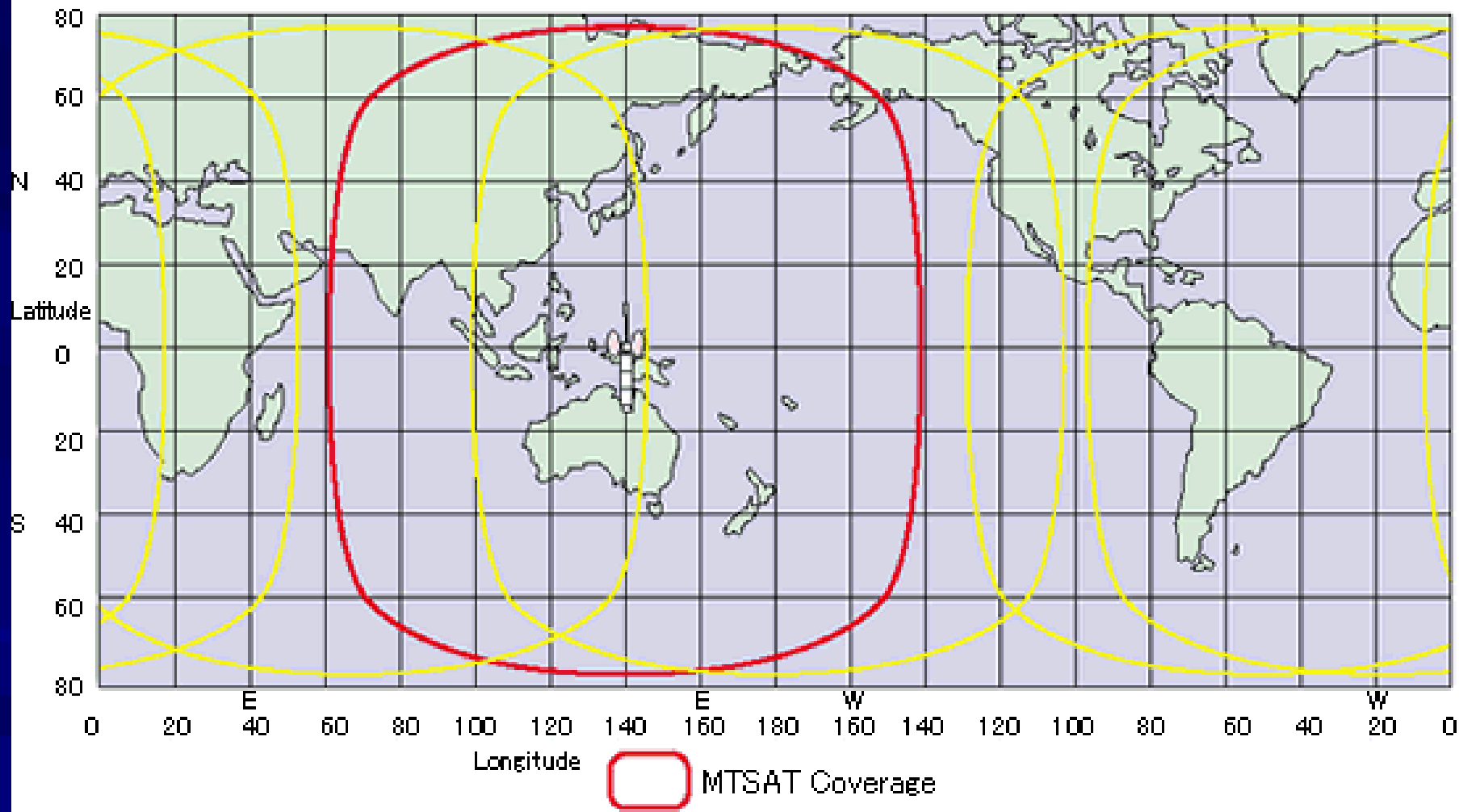
CLR

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FN



MTSAT Global Beam Coverage (L-band)



MFD

APOLLO MX20

Waypoint:
+4S2

Wpt Bearing:
064



Zoom: 30 n m Alt: 1,200 f Baro: 28.70" Trk: 064° GS: 100 k Distance: 31.1 n m

MSG In Out Pan Info Custom Map

OFF

MENU ENT

FN

GARMIN G1000



NEW AIRCRAFT

- TSO C146 Receivers
 - GPS
 - VOR
 - ILS
- **Not fitted with ADF**
 - **Includes airlines aircraft**
- RNAV “primary means” approval
 - Needs the RPS for planning

GNSS Approvals

- Primary Means Domestic Enroute – 1995
- GPS Arrivals - 1995
- GPS Oceanic - 1998
- GPS Non Precision Approaches – 1998
- GPS in Lieu of DME
- GPS Separation Standards
- GPS Safety Heights
- FANS B747, Most Airline Aircraft (Defence??!!)

GNSS APPROVALS (2)

- RNP 0.1 NM into Queenstown
 - B737-800
 - 35 extra passengers
 - Guided departures
- ADS-B 2006
 - 5 NM Separation Standard Approved
- Primary Means with TSO C145/6 receiver
 - Equivalent to VOR or NDB
- RAIM Predictions Systems
 - 1998 Airservices Australia system – Volpe US DoT
 - 2006 – with C145/6 and FDE

GPS ENROUTE

- **Approved in 1995**
 - Primary Means
 - Single TSO C129 Receiver
 - With Baro-Aiding
 - Domestic FIR
 - 1% immediate fuel saving
 - Used by practically all IFR operators
- 12 NM separation standard
 - 10 minutes of non RAIM ops allowed
 - **No Enroute Prediction Required**
- RNAV routes using GPS
- Savings around \$50 mil per year in 1996
- No reported interference in 12 years
- No Reported RAIM losses

RNAV (GNSS) APPROACHES

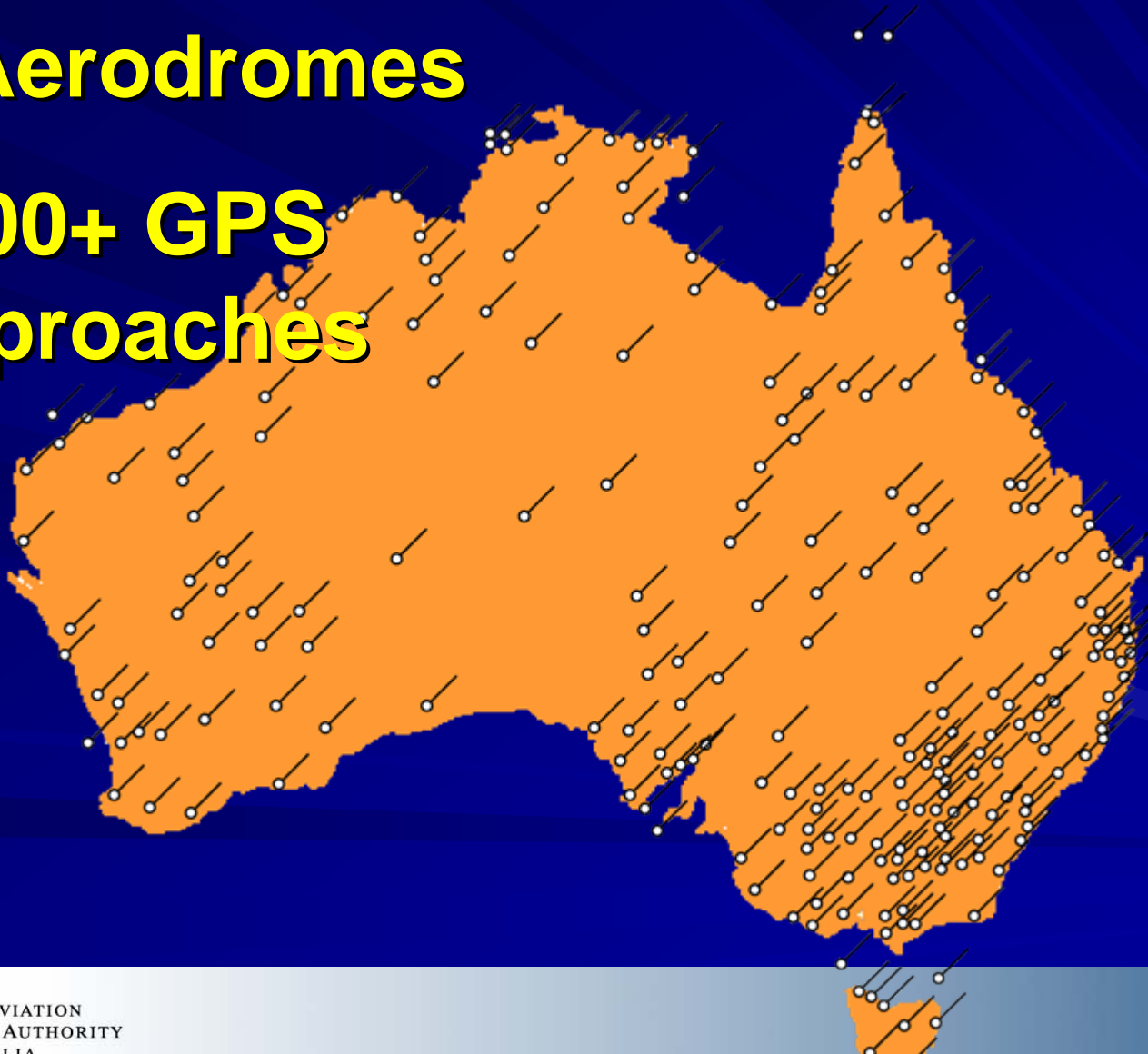
Approved in 1998



Aerodromes with GPS/NPA

272 Aerodromes

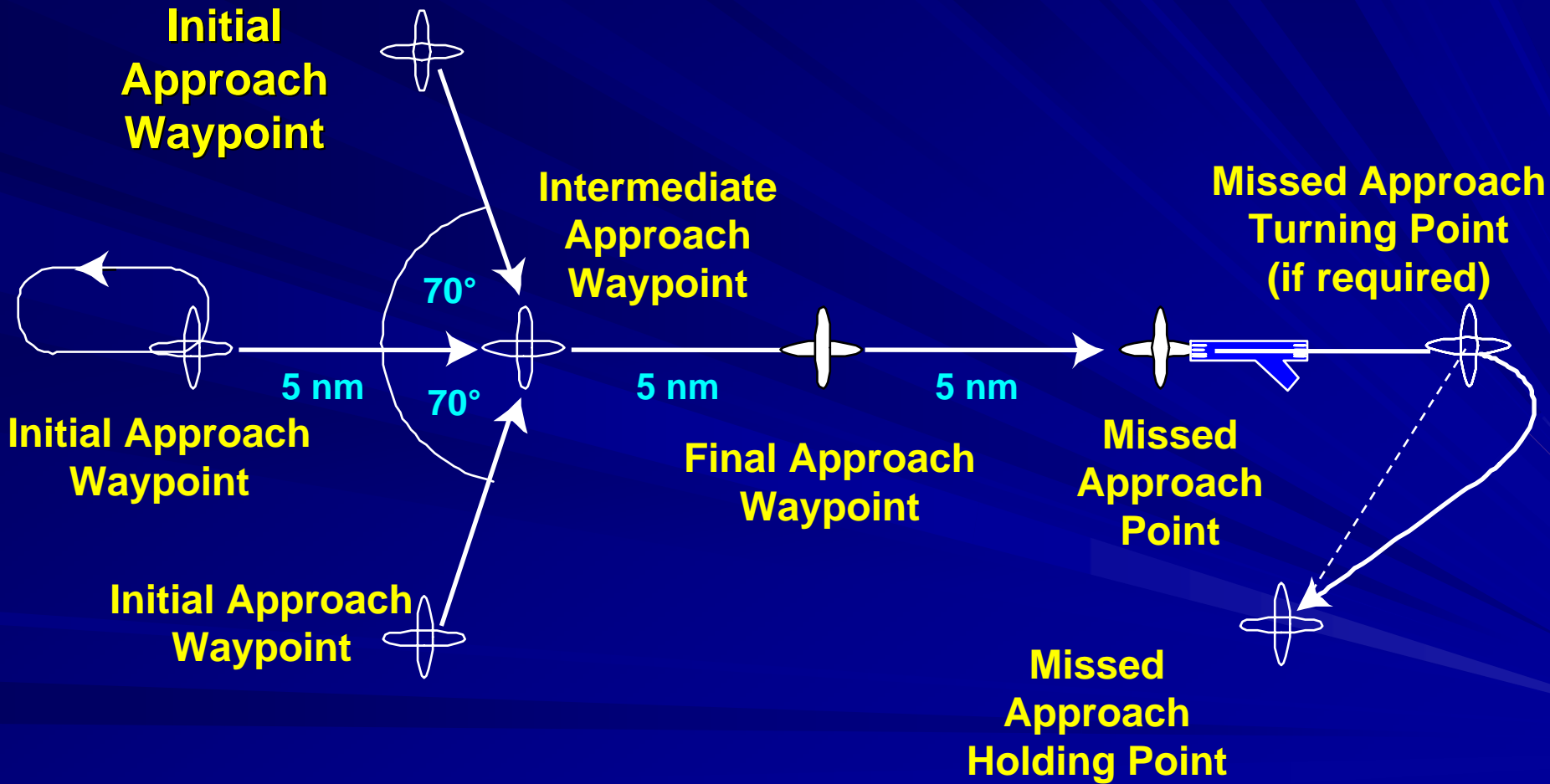
**500+ GPS
approaches**



GPS APPROACHES

- ICAO Pans Ops
 - Based on US TERPS
- Approved in 1998
 - 500+ approaches
 - Used by GA and airlines
 - Boeing 737, A320, A330
 - “25” times safer than circling NPA
- RAIM prediction system on web site
- GPS Training Material – videos, slides etc

Approach Design



RAIM PREDICTION

- Available on Airservices Web Site
 - www.airservicesaustralia.com
 - Supplied to other countries
- Is a NOTAM
- Uses GPS Receiver plus Status Messages
- More accurate than receiver
- Two types
 - C129 and C145/6 with FDE
 - Also oceanic prediction
- Highlighted **errors** in Status Messages

YSCB

TSO-C129(a) (and equivalent) Fault Detection

0703100409 TIL 0703100419

0703110405 TIL 0703110415

GPS RAIM FD Unavbl for NPA TSO-C146a (and equivalent) Fault Detection Only

No GPS RAIM FD Outages for NPA TSO-C146a (and equivalent) Fault Detection and Exclusion

0703090749 TIL 0703090756

0703090824 TIL 0703090834

0703100409 TIL 0703100426

0703100438 TIL 0703100458

0703100741 TIL 0703100809

0703100816 TIL 0703100830

0703101609 TIL 0703101618

0703101625 TIL 0703101632

0703110405 TIL 0703110422

0703110434 TIL 0703110454

GPS RAIM FDE Unavbl for NPA

INTERFERENCE

- No reported IFR interference
- Installation Interference
 - 99%+ of all reported
- TSO C145/6 receivers far better in testing
- **DoD Trials**
 - **Need to be closely managed and monitored**
- Jammers banned in Australia
- Strong Frequency Protection – ACA
- Will need isolation in busy environment

ACCIDENTS

- Three “RNAV (GNSS) Accidents”
 - Reports on www.atsb.gov.au
 - Two were ‘piloting’ errors
 - One unresolved – 11km offset in position
 - Possible Antenna Error???
- ATSB Survey of Pilot Attitudes to RNAV (GNSS)
 - Waypoint naming
 - Level of difficulty ‘second to NDB’
 - Orientation, Step Down Fixes, Receiver Use
 - Value of APV Approaches

SUMMARY

- WGS-84 Essential
- Basic GNSS provides high returns
 - Enroute RNAV
 - RNAV (GNSS) Approaches
- APV is ICAO preference
 - RNP APV is available now!
- Ensure ICAO RNP Manual is used
- New Approvals Should be based on TSO C145/6
- RNP +ADS-B = Airspace Heaven!!!

B737-800



RNP BENEFITS

■ Safety

- Runway aligned DA – almost anywhere
- Lateral & vertical guided approaches
- CFIT risks reduced
- Use of automatics
- Engine INOP solutions

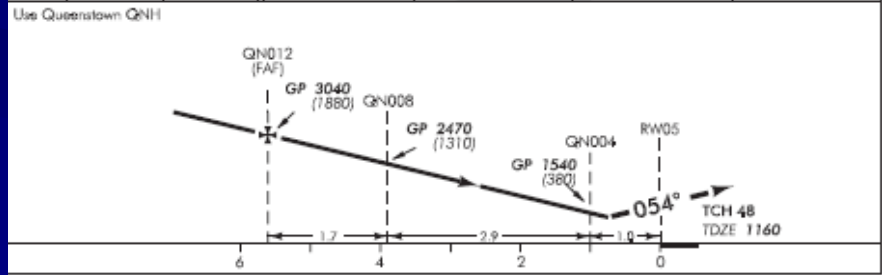
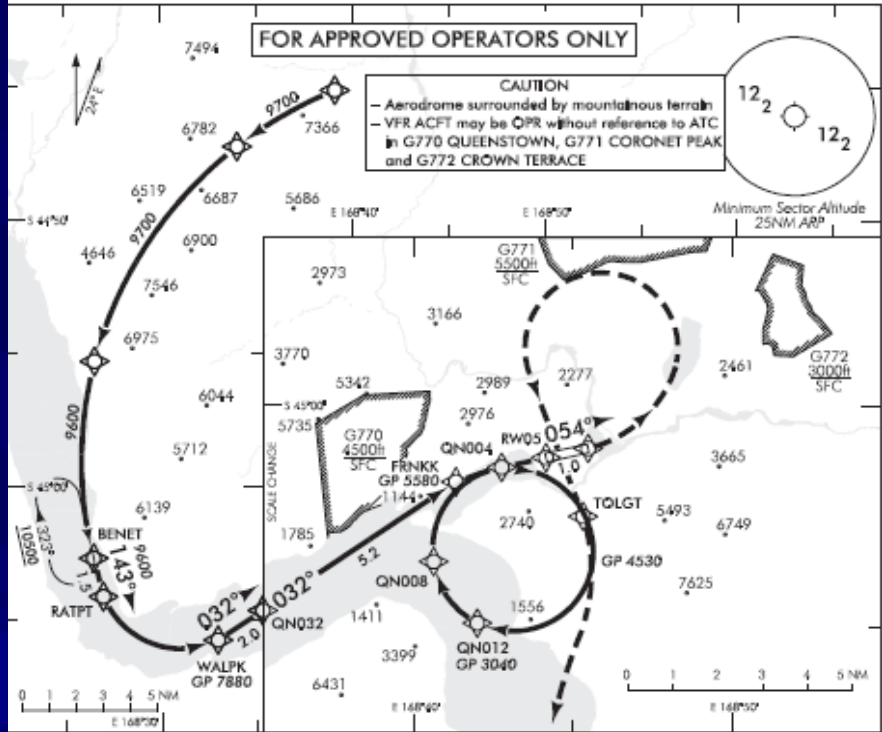
■ Operations

- Departure uplift **+35 additional passengers!**
- Significantly Lower Minima (-1100')
- Great cost benefit outcome

■ Efficiency – saves some 2-300 kg fuel per flight

■ Environment – reduced noise footprint





MISSED APCH: Climb to 9800 via the RNP RNAV missed approach track

Category	A	B	C	D
RNPO.10	NA		1434(274) - 2000	
RNPO.15			1488(328) - 2000	
RNPO.18			1501(341) - 2000	
RNPO.30			2361(1201) - 5	



Sydney GLS



GLS STATUS

- FAA have reverted to “R&D” status
 - Due design issues
 - FAA certification “early 2009”
- Aircraft OEMs – GLS Receivers certified
 - B737-800, A380 etc
 - No certified ground systems
- Qantas/Sydney GPS installation

A380 USED GLS INTO SYDNEY



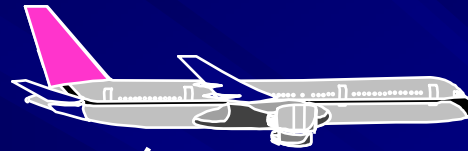


ADS-B in Australia



Radars Like Application

“ADS-B OUT”



**POSITION, ALTITUDE, IDENTITY(CALLSIGN),
VELOCITY VECTOR, VERTICAL RATE**

**Typically
broadcast 1/second**



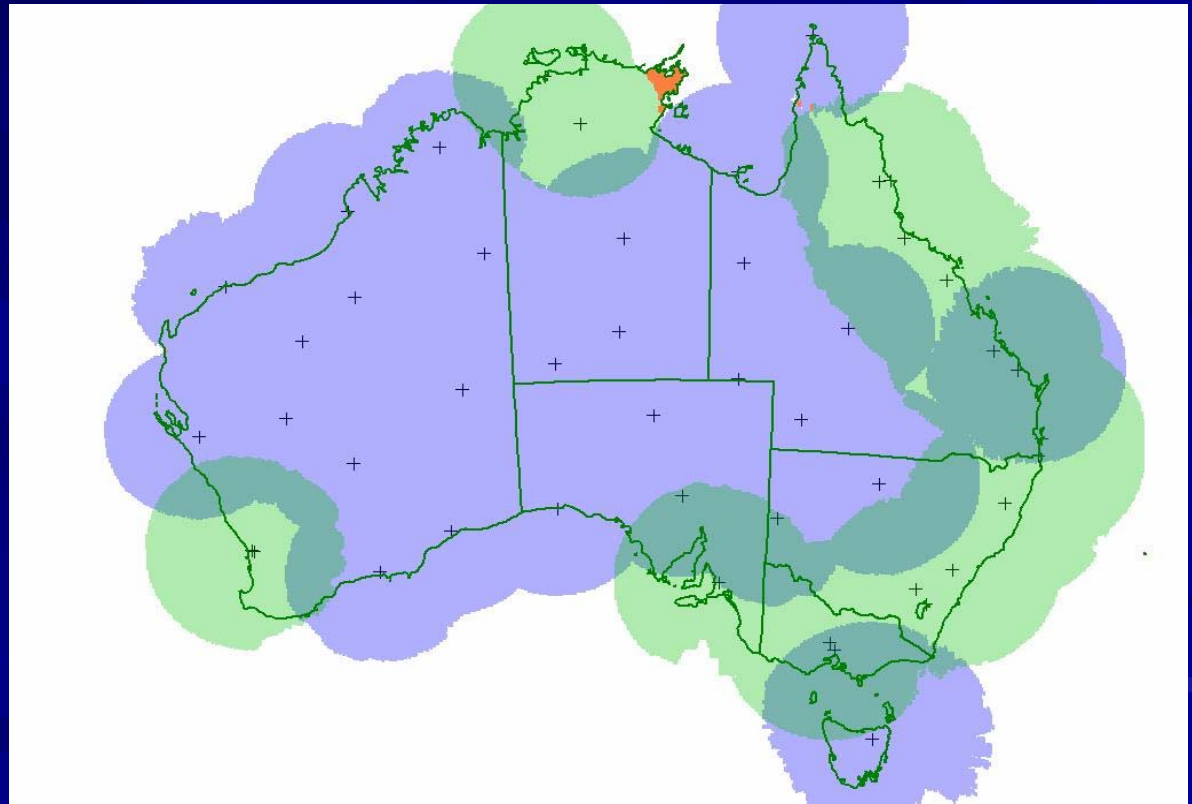
ADS-B Ground station



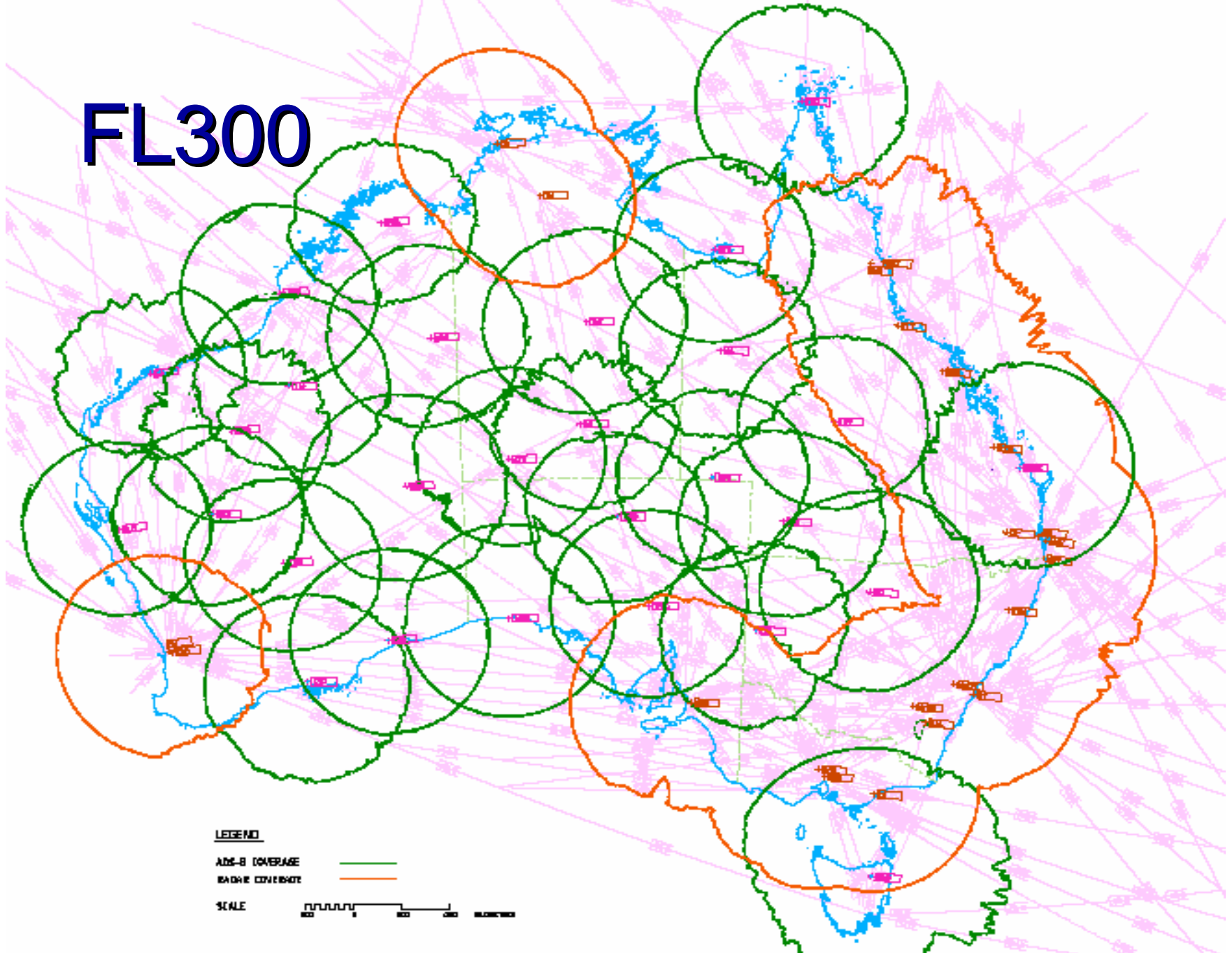
UPPER AIRSPACE PROJECT

28 ground stations are being deployed at existing communications sites throughout outback Australia



...expanding high level automatic air traffic surveillance capability from less than 20% of the Australian continent to over 99%.



FL300



LEGEND

- ADS-B COVERAGE 
- RADAR COVERAGE 

SCALE 

ATLAS PROJECT

- Mandate ADS-B carriage
 - EOY 2013
 - Funding provided for GA installation
- Main benefits
 - Adoption of GNSS RNAV
 - No Replacement on enroute SSR Radars
- Nav Aid Rationalisation Program
 - Reduction in ADFs and VORs



APPROACHES WITH VERTICAL GUIDANCE

APV

ICAO APV DECISION

- ICAO CFIT Study – now Required
- Up to 8 times safer than circling NPA
- Vertical Guidance is the Key!!
- ICAO 100% APV by 2016
- Adopted by APANPIRG in Regional Plan
- Booz Cost/Benefit Study
 - Baro-VNAV APV First

APV TECHNOLOGIES

- Baro-VNAV RNP B738-800
- Augmented GNSS
 - SBAS (US WAAS – 900 LPVs)
 - Now approved to 200'/1/2 NM visibility
 - Japanese MSAS will be operational in IQ/2007
 - Visible in Australia
 - GBAS
 - GLS in Sydney – certification in early 2009
 - GRAS
 - Development now on hold
- Combined Systems
 - GPS + Galileo

ELECTRONIC AIS

- **1 bit of data in 1000 is WRONG!**
 - EC Study
 - Unsuitable for RNP 2
 - State Data have large errors
 - Third party providers doing quality control
- Major issue with RNP Approaches
 - Needed additional integrity measures to make it work safely
- Electronic Flight Bag (EFB) etc now here
- Data Integration – eg Terrain and AIP
 - eTOD ICAO requirements
 - Large terrain errors – 2000'+
- **Solution** = Single Electronic System
 - AIXM as ICAO Standard = EAIP
- Government – “Regulate AIS”
- Current data base is required for IFR

Performance Based Navigation

Airspace Concept

COM

NAV

SUR

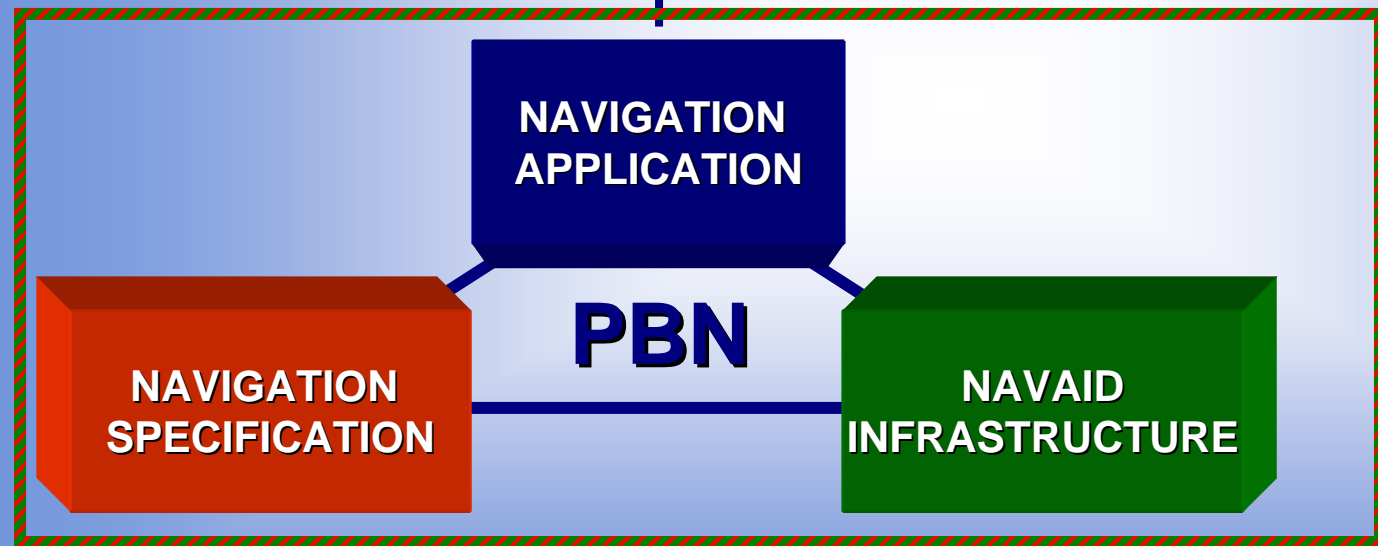
ATM

**NAVIGATION
APPLICATION**

PBN

**NAVIGATION
SPECIFICATION**

**NAVAID
INFRASTRUCTURE**





OUTCOME

- APAC Region moving to a satellite-based infrastructure
 - Enroute
 - RNAV (GNSS) Approaches
 - Baro-VNAV Approaches
 - RNP-AR
- PBN Based System
- Wide variation in Implementation
- **Safety – Efficiency - Environment**

GNSS ADOPTION

- Most people unaware of GPS use
 - Timing, finance, agriculture
- Quite revolution!
- Complete acceptance

- Car navigators have saved many relationships!!

AUSTRALIAN WEBSITES

- www.airservicesaustralia.com
 - Publications, RAIM prediction, ADS-B Program
- www.casa.gov.au
 - GPS approvals
- www.astra.aero

Good Bye

- Airservices GRAS Project cancelled
- GLS going ahead
 - Approval by FAA in early 2009
- Keith McPherson sends his regards
 - Pursuing new goals
 - Contact details available

CONTACT

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**QUESTIONS
&
DISCUSSION**



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