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ADS-B Technology basics

ADS-B Workshop – SP/14

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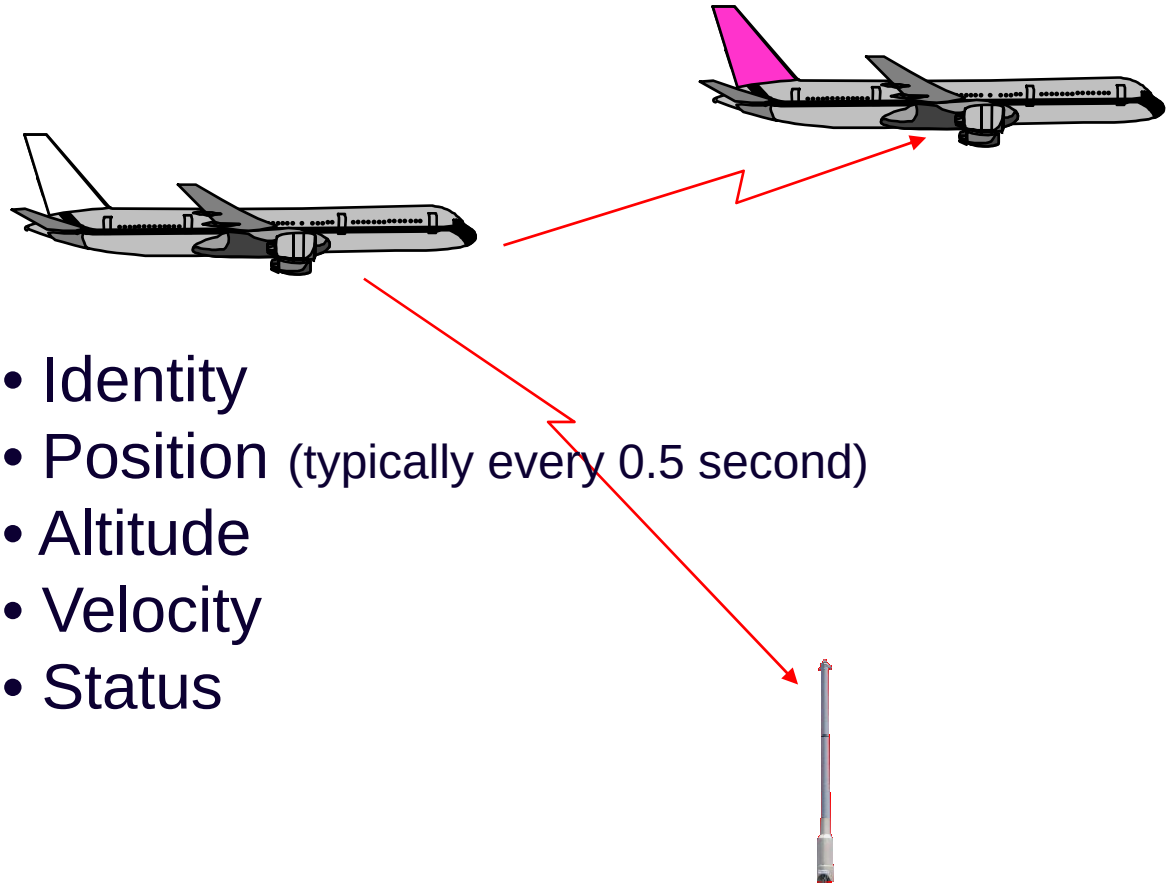

- Identity
- Position (typically every 0.5 second)
- Altitude
- Velocity
- Status

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What is ADS-B?

- *Automatic*
  - ✈ no pilot input required
  - ✈ no radar interrogation required
- *Dependent*
  - ✈ extremely accurate position and velocity vector from aircraft
- *Surveillance*
  - ✈ aircraft position, altitude, velocity vector, + . . .
- *Broadcast*
  - ✈ any ground station or aircraft can monitor

How ADS-B Works

- Aircraft determines its position (typically) using GPS
- Broadcasts position, identity, altitude and velocity information (ADS-B out)
- Ground stations receive the broadcasts and relay the information to air traffic control
- Other aircraft receive broadcasts & display to pilot (ADS-B in)

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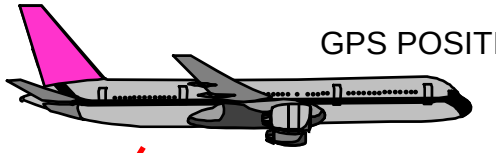
ADS-B “OUT”

GPS POSITION

GPS POSITION



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

Typically two broadcasts / second

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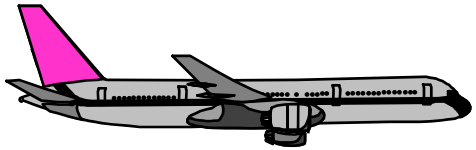
Air-Ground Surveillance

ADS-B “IN”



Transmissions defined in ICAO standards

Enhanced “See & Avoid” Air-Air Surveillance

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Traffic Displayed on MFD or PDA

SSR background

AIRCRAFT

1030Mhz Interrogations 3 pulses (P1,P2,P3)

ModeA, C interrogations

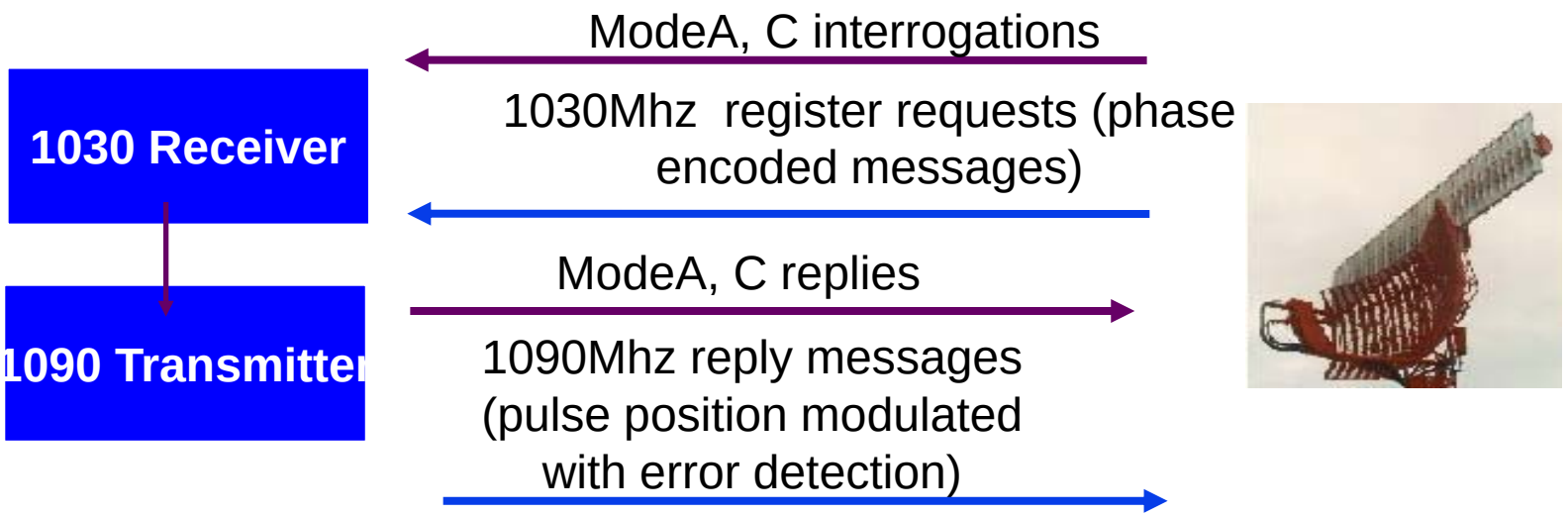
1030 Receiver

1090 Transmitter

ModeA, C replies

1090Mhz reply messages 12 pulses
(no error detection)

MODE S background



Readout :
“Registers”

TCAS background

1030Mhz Interrogations 3 pulses

1030Mhz register requests (phase encoded messages)

1090Mhz reply pulses

1090Mhz reply messages (pulse position modulated with error detection)

1030 Receiver

Transmit DF11

1090 Transmitter

Receive ModeC replies

Receive DF11

Receive DF0

1090 Receiver

TCAS LOGIC & Display

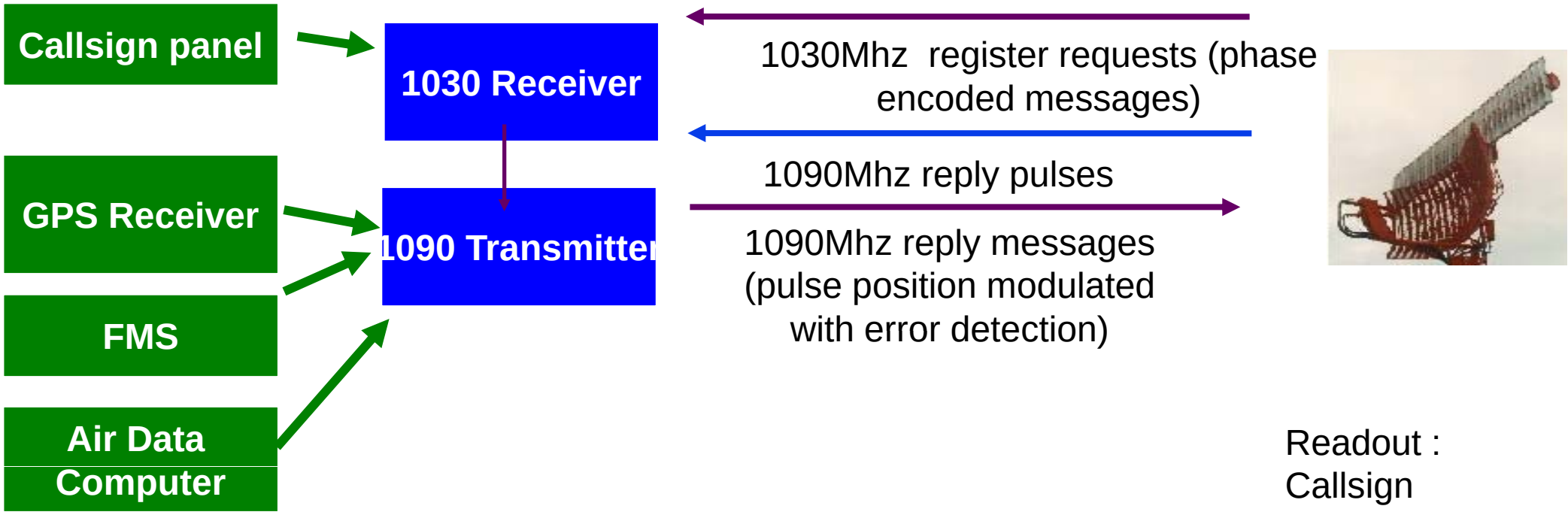
1030 Transmitter

Mode C interrogate

Mode S interrogate (UF0)

Enhanced & Elementary Surveillance

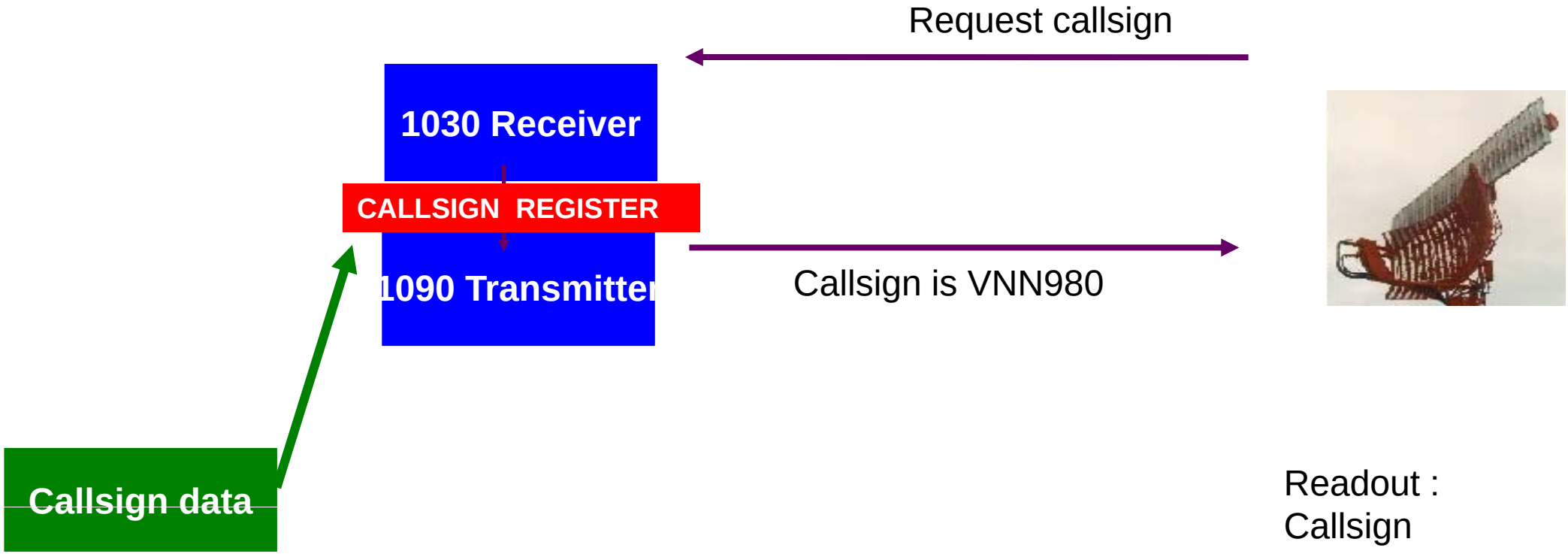
DATA to FILL the REGISTERS



Readout :
Callsign
Bank angle
Selected level
Airspeed
Heading

Enhanced & Elementary Surveillance Example

DATA to FILL the REGISTERS



Readout :
Callsign
Bank angle
Selected level
Airspeed
Heading

ADS-B background

GPS Receiver

1030 Receiver

1090 Transmitter

TRANSMIT
DF17/18 ADS-B

1030Mhz Interrogations 3 pulses

1030Mhz register requests (phase encoded messages)

1090Mhz reply pulses

1090Mhz reply messages (pulse position modulated with error detection)

1090 Receiver

TCAS LOGIC & Display

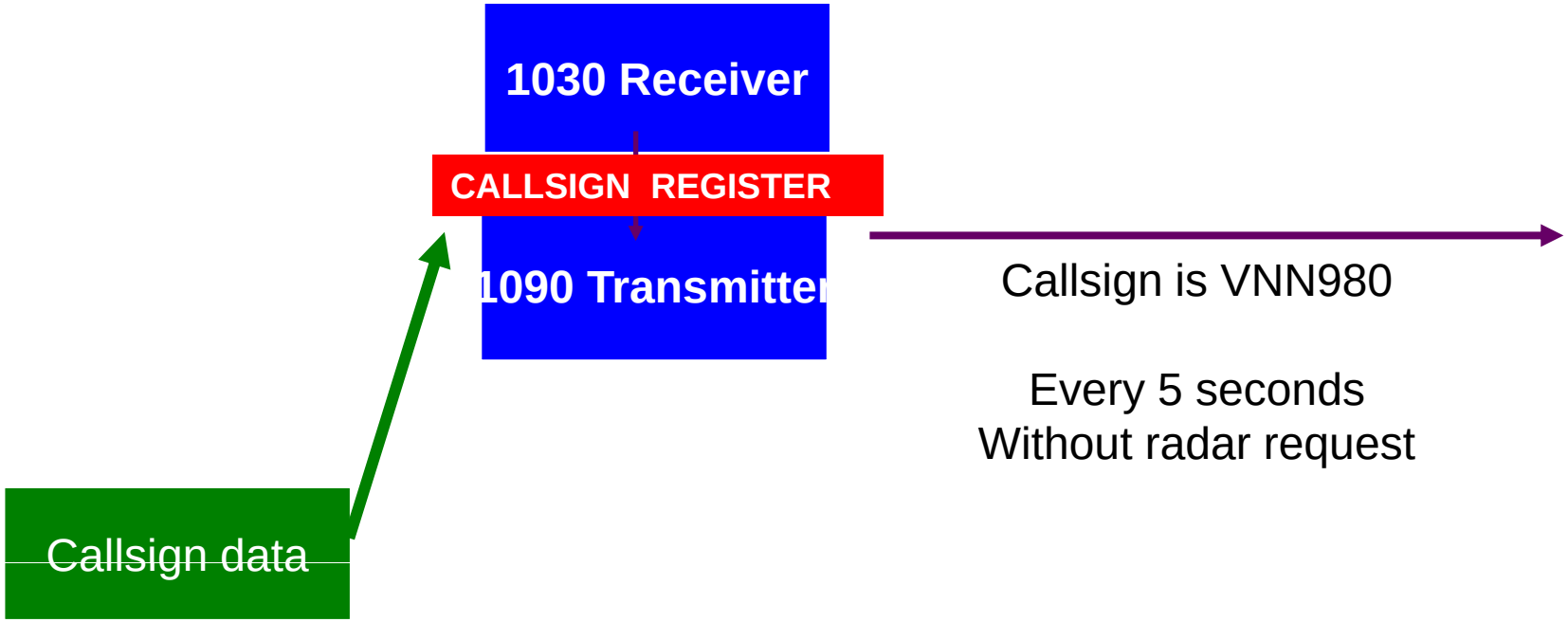
Receive
DF17,DF18
ADS-B
& display

1030 Transmitter

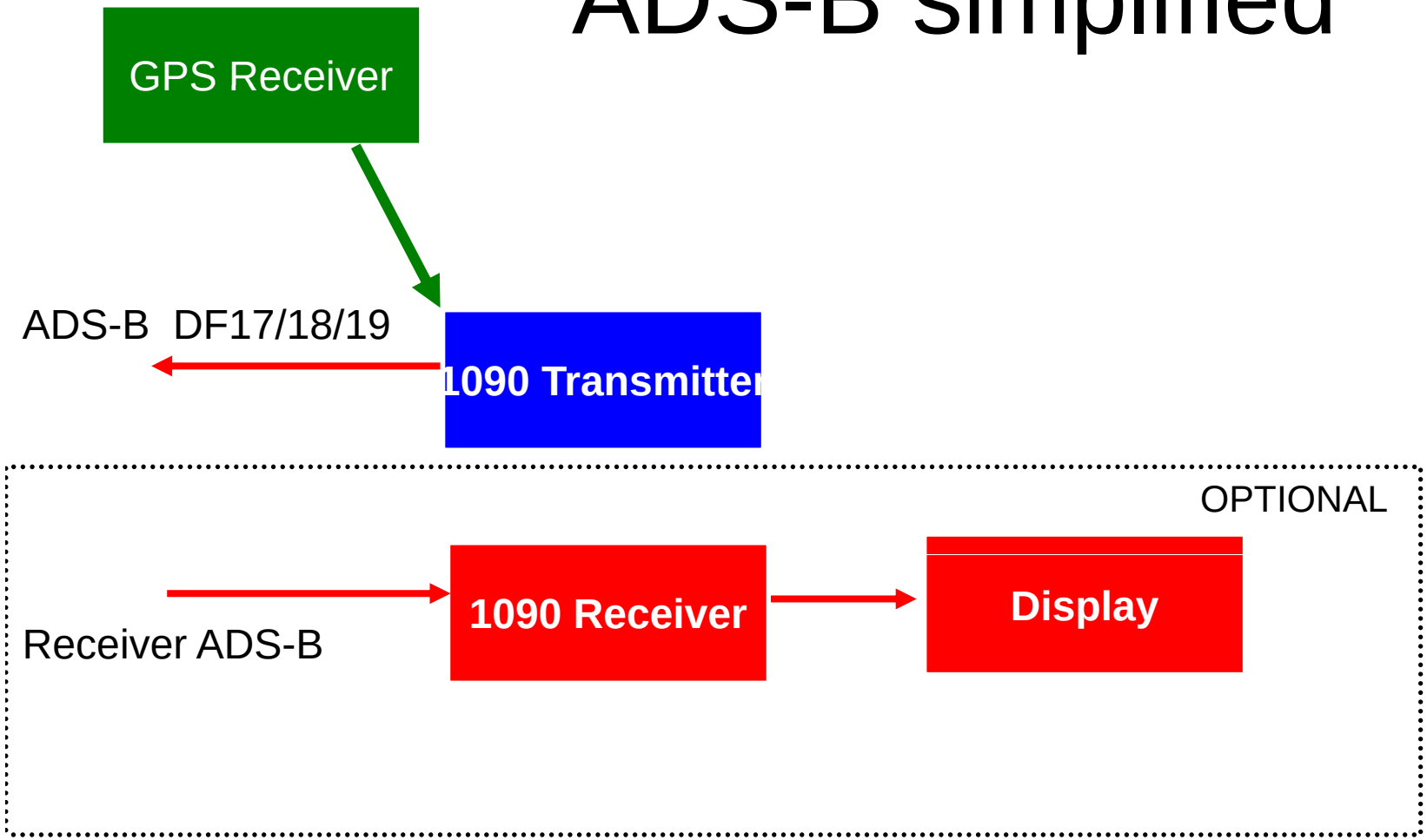
Mode C interrogate
other aircraft & Mode S encounter

ADS-B example

DATA to FILL the REGISTERS



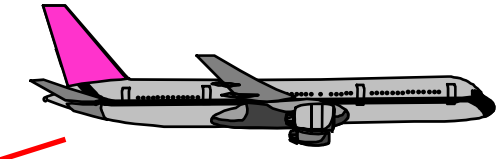
ADS-B simplified

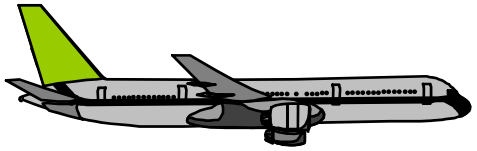


Mode S

24 bit code DF11 acquisition squit (TCAS : Here I am)

CONTROL	24 bit AIRCRAFT ADDRESS	PARITY





ADS-B

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

CONTROL	24 bit AIRCRAFT ADDRESS	ADS-B MESSAGE 56 Bits	PARITY

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Mode S Transponder & ADS-B

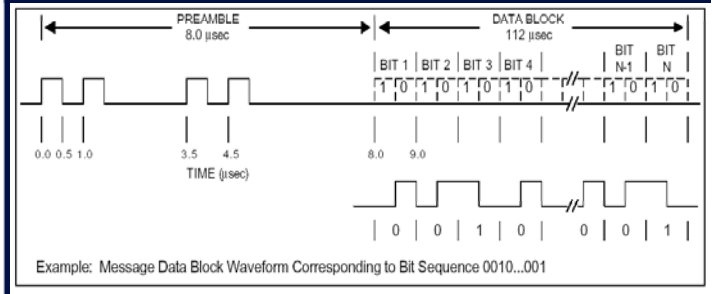

Figure 2-1: ADS-B Message Transmission Waveform

ADS-B is an unsolicited Mode S transmission using similar formats

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Burnett Basin Trial Experience in 2002

Performance is great

5 Nm Separation services delivered


BRISBANE TERMINAL AREA RADAR TOWER
ADS-B ANTENNA

ADS-B ground stations are simple and economical

ADS-B
~ $100K-$400K USD

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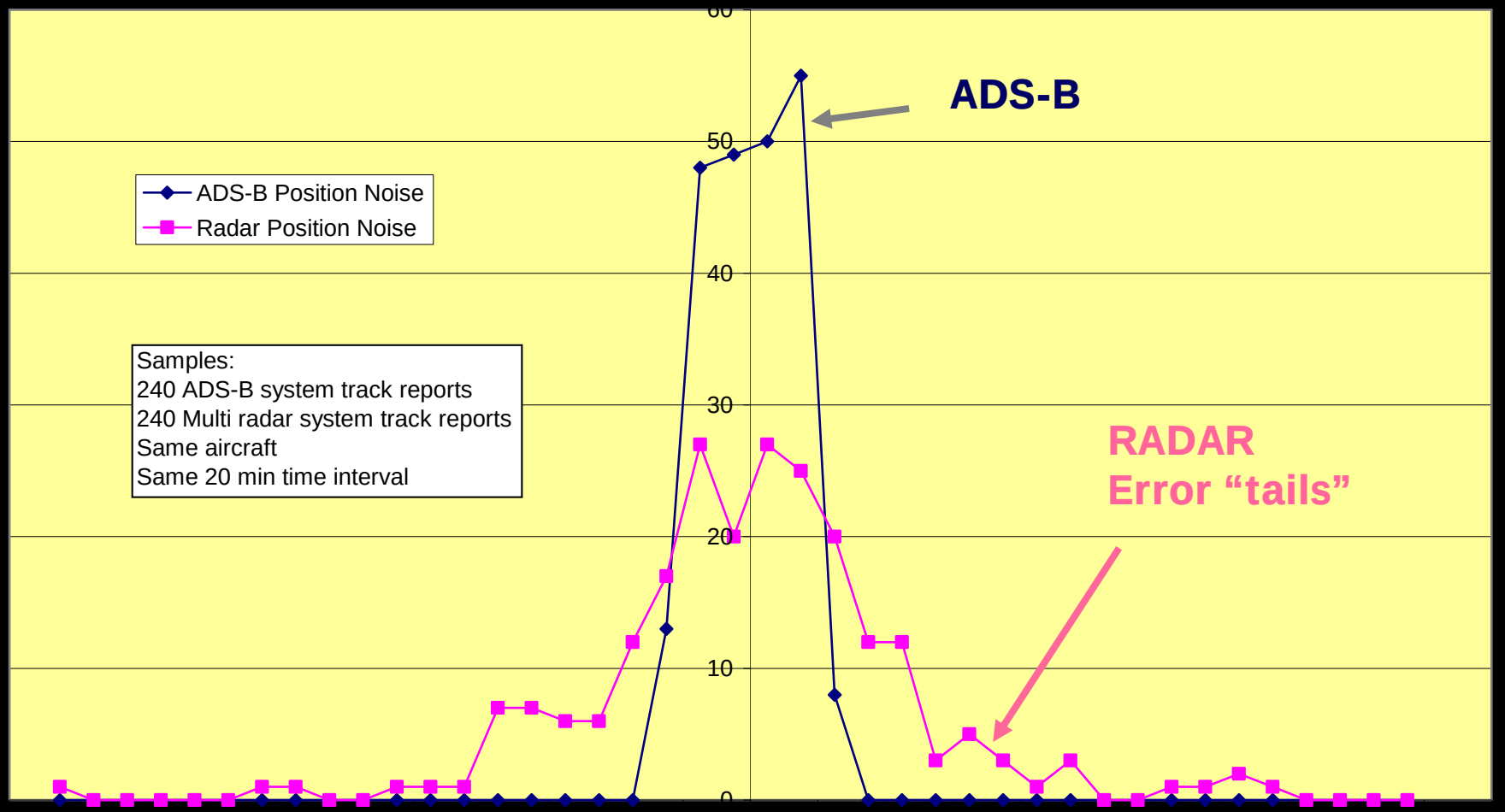
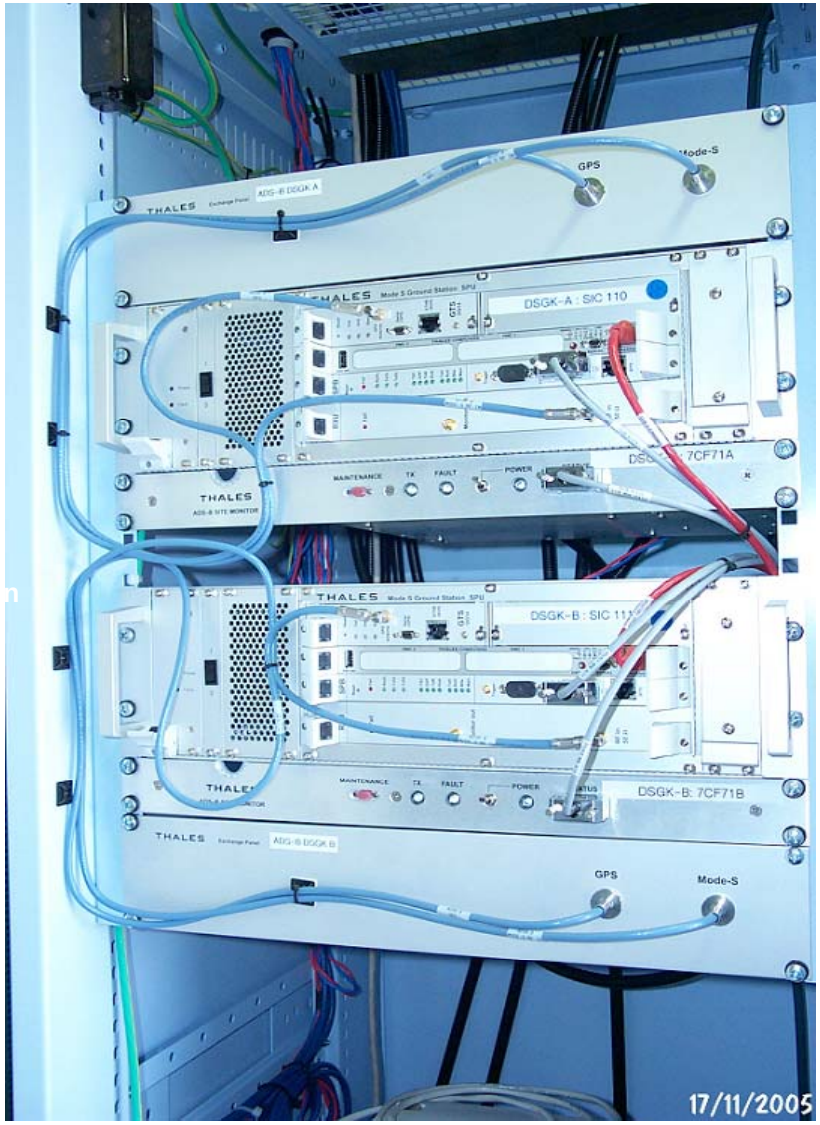
Cost Comparison

Maintenance
Power
Site space
Building
Road
Environmental
Rotating machinery

RADAR
~ $1M - $4M USD

Radar & ADS-B Noise





Dual ADS-B Ground station

24 v operation
<100 watts

Site monitor included

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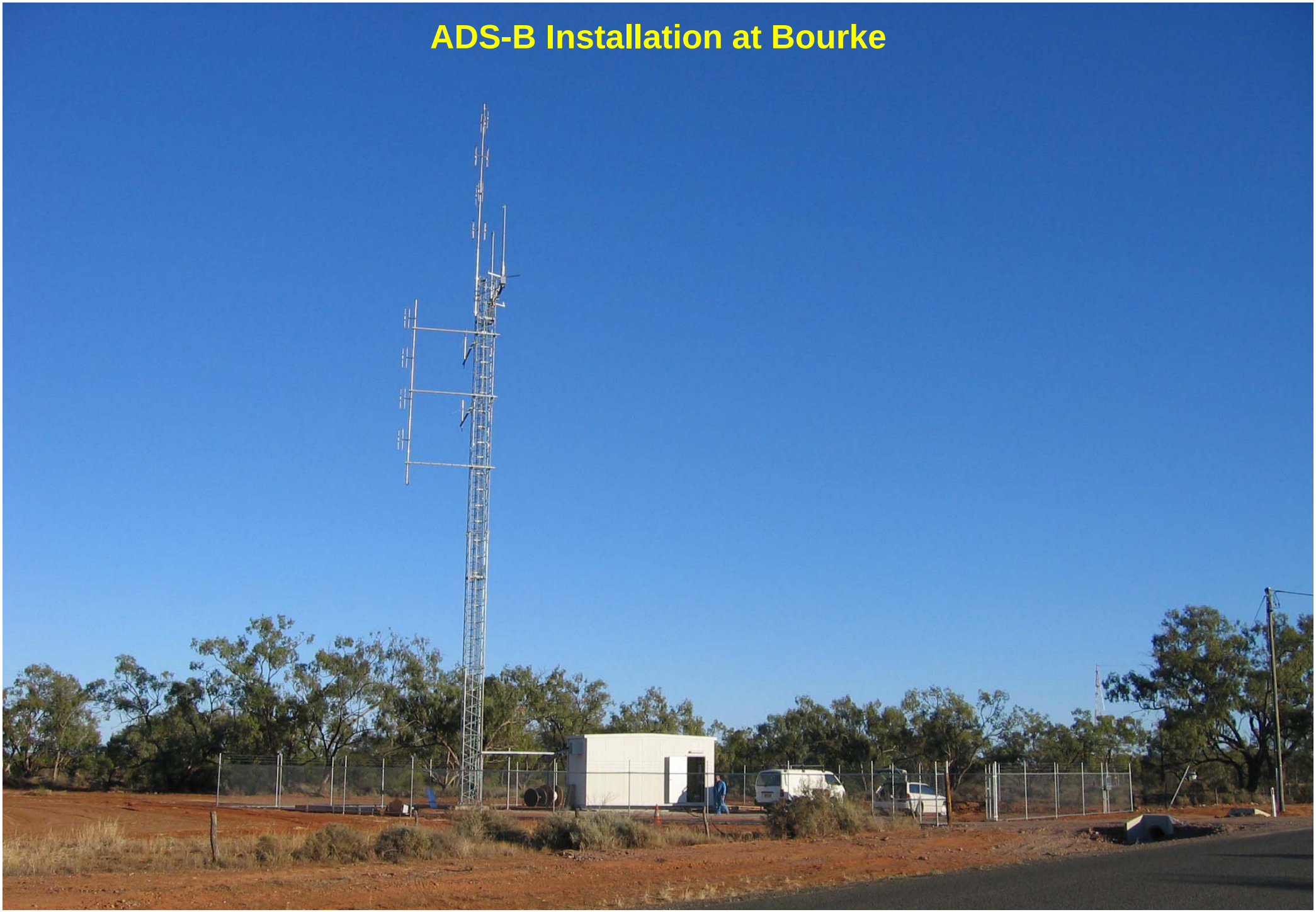
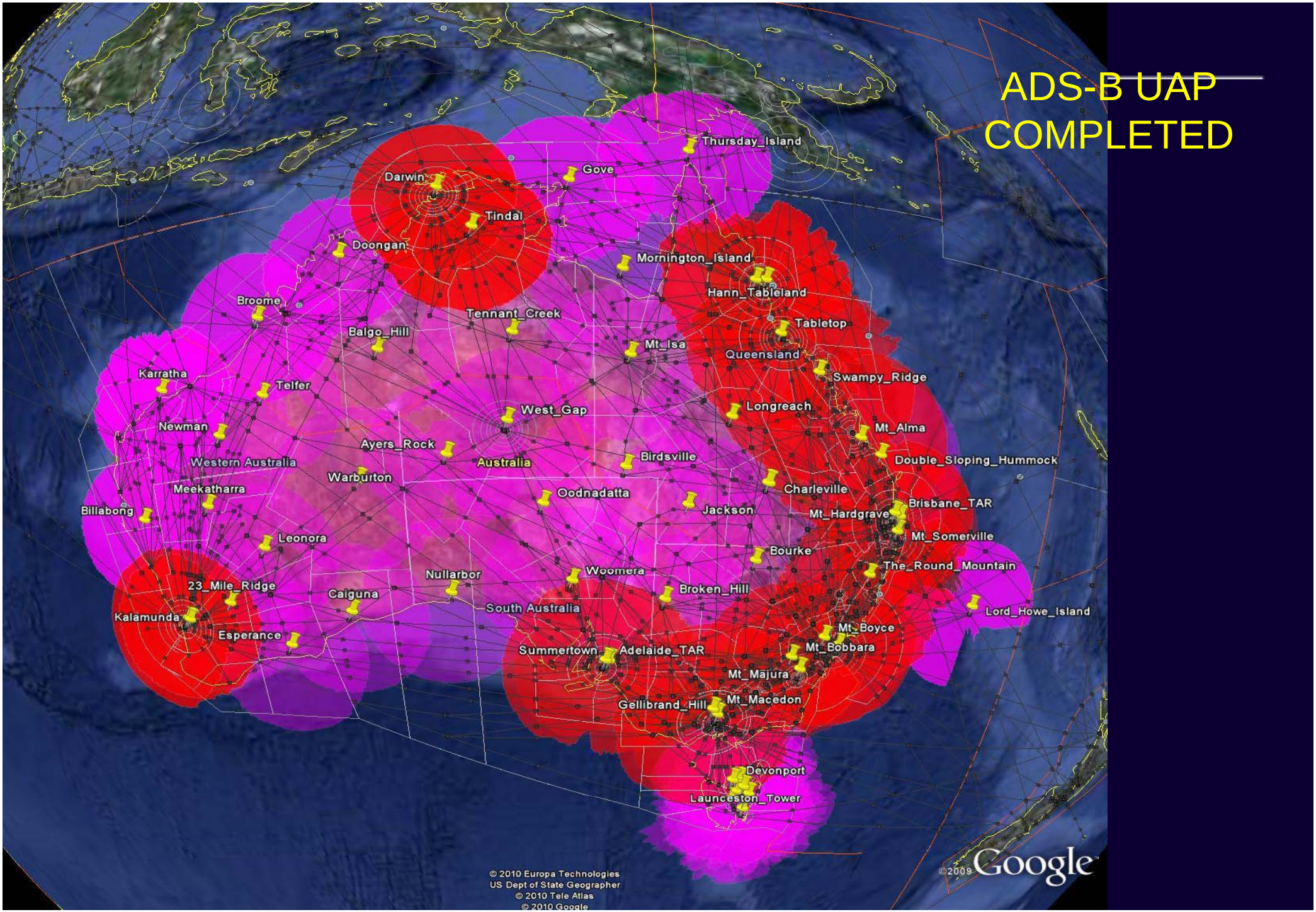
ADS-B Installation at Bourke




ADS-B UAP
COMPLETED
Thursday_Island
Darwin
Gove
Tindal
Doongan
Mornington_Island
Hann_Tableland
Broome
Tennant_Creek
Tabletop
Balgo_Hill
Mt_Isa
Queensland
Karratha
Swampy_Ridge
Telfer
West_Gap
Longreach
Newman
Mt_Alma
Ayers_Rock
Australia
Birdsville
Double_Sloping_Hummock
Western Australia
Warburton
Charleville
Meekatharra
Oodnadatta
Brisbane_TAR
Billabong
Jackson
Mt_Hardgrave
Mt_Somerville
Leonora
Bourke
The_Round_Mountain
Nullarbor
Woomera
23_Mile_Ridge
Broken_Hill
Caiguna
Lord_Howe_Island
South Australia
Kalamunda
Mt_Boyce
Esperance
Summertown
Adelaide_TAR
Mt_Bobbara
Mt_Majura
Gellibrand_Hill
Mt_Macedon
Devonport
Launceston_Tower
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UAP Stage 3 became Operational on 18/12/2009

- 27 Ground stations on ATC displays
- Authorised for 5 Nm separation across the continent
- Controller training completed
- Operational approval granted
- Notam issued

C8395/09 NOTAMN
Q) YUXX/QXXXX/IV/BO/E/000/999/
A) YMMM/YBBB
B) 0912181400 C) 1001310600 EST
E) SURVEILLANCE SEPARATION AVBL OUTSIDE RADAR COVERAGE IN BRISBANE AND MELBOURNE FIR DUE ADS-B UPPER AIRSPACE PROGRAM STAGE 3 IMPLEMENTATION COVERAGE DETAILS AVAILABLE AT WWW.AIRSERVICESAUSTRALIA.COM/PROJECTSSERVICES/PROJECTS/ADSB/UAP.ASP

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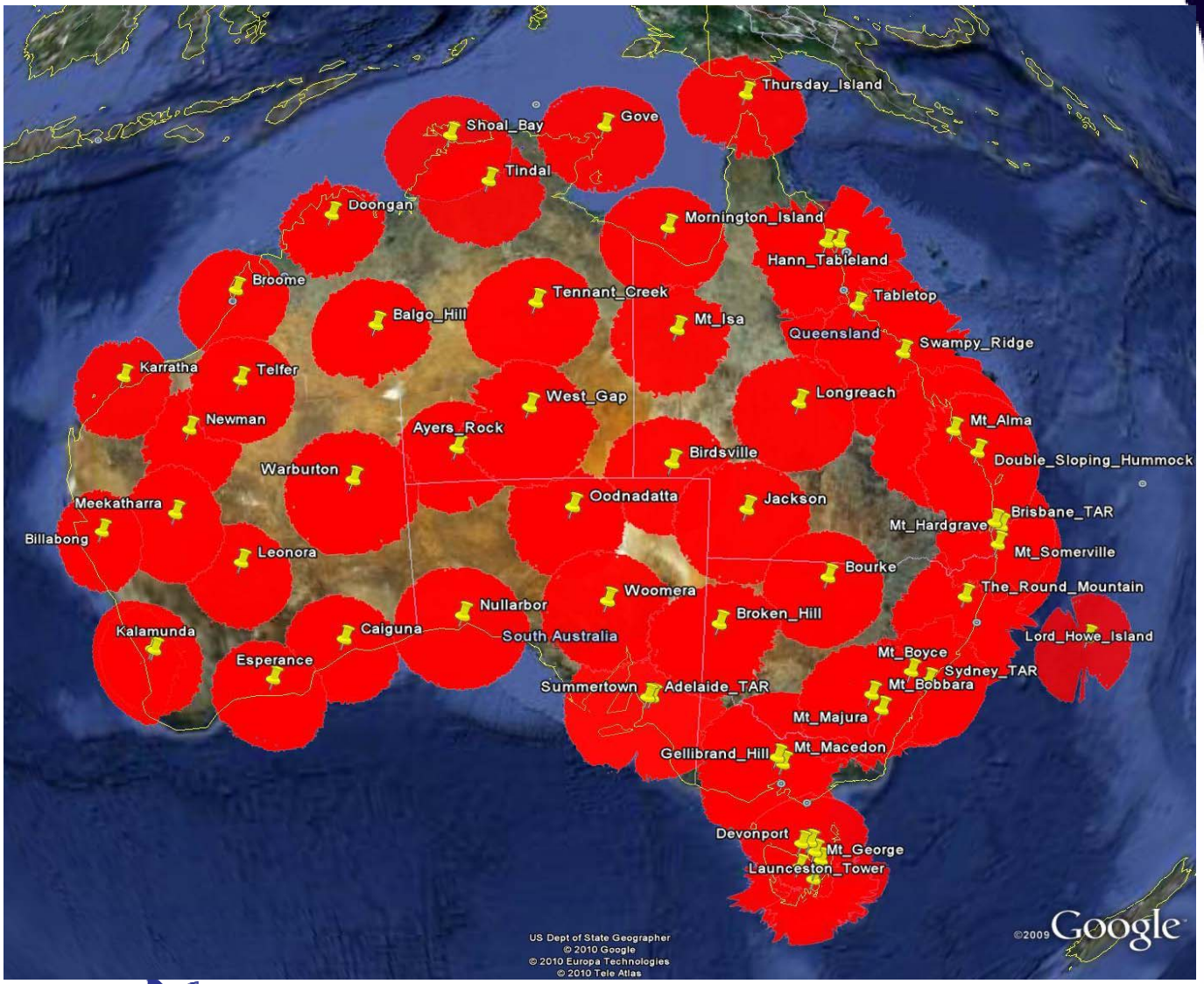

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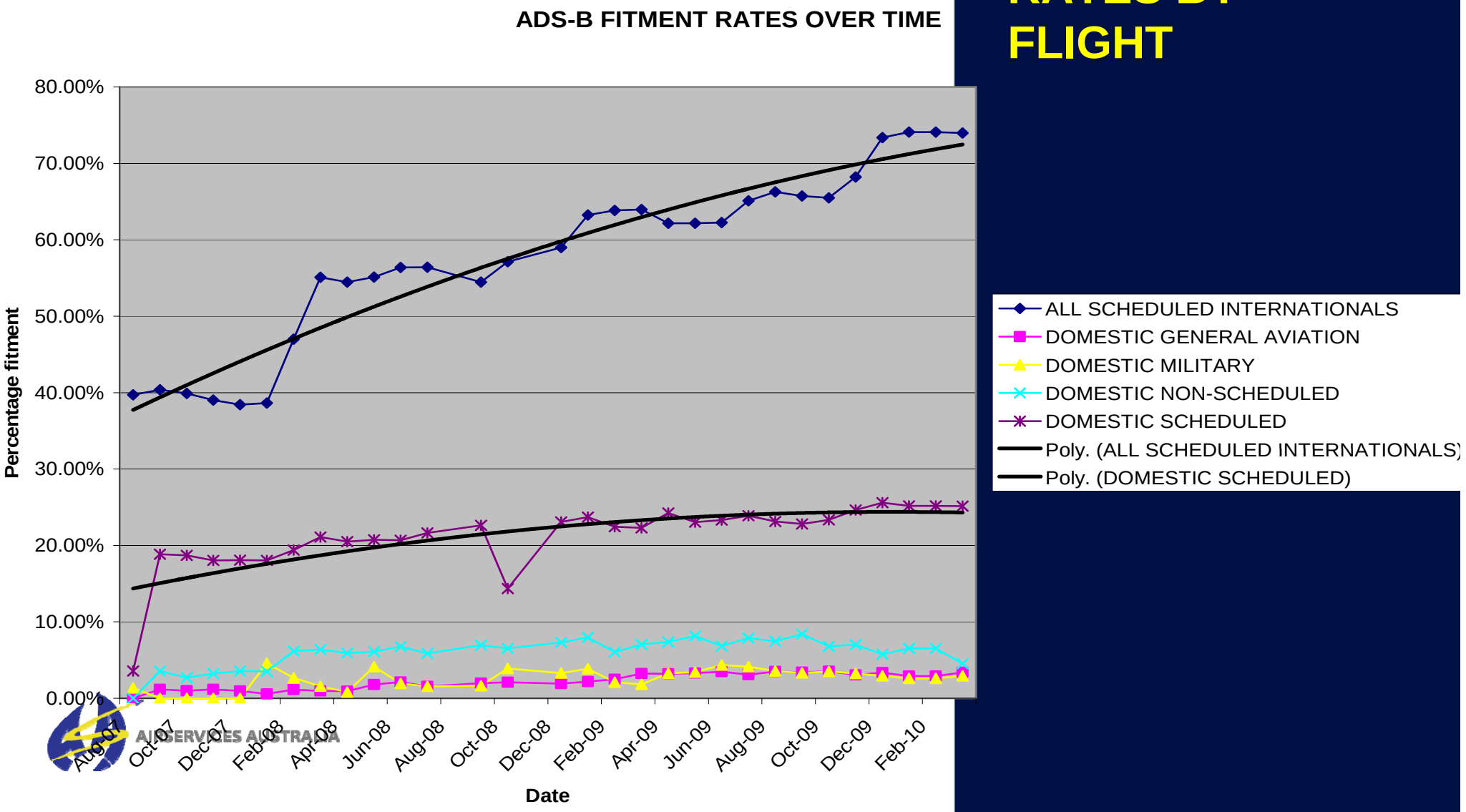
10,000 feet

ADS-B already provides significant coverage in lower level airspace

ADS-B FITMENT RATES BY FLIGHT



SOME LESSONS LEARNT

- ADS-B performs very well
- Some loss of service due inadequate GPS
- Only a few teething problems
  - Incorrect Flight ID in B747
  - One manufacturer using HFOM instead of HPL
  - One manufacturer reporting NUC 1 step less than actual
  - One manufacturer position jumps (CPR decoding & now a second cause)
- Better education required for avionics installers
  - Installation complexity with DO260A (SIL etc)
  - Inadequate knowledge regarding HPL
- ADS-B data sharing can bring big safety benefits

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ADS-B sharing supports safety at FIR Boundary discontinuity

- Every FIR boundary represents a
  - » Discontinuity
  - » Different database
  - » Risk, errors, different views of “true” situation
- Surveillance provides
  - » Feedback (closes the loop)
    - – Rather than 30 minute position & level reports
  - » Detects errors/ blunders
    - – ATC, pilot, other ATC
    - – Minimises the IMPACT of errors
- ADS-B provides inexpensive means to share data
  - » For co-operative aircraft
  - » No threat to military

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Example

FLIGHT ID : CALLSIGN

POSITION &
INTEGRITY

GPS/ MMR

TRANSPONDER

ALTITUDE

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Key components

- Transponder
  - » ADS-B capable model
- GPS or MMR
  - » Provides integrity data
- Panel or system to provide CALLSIGN

HPL / HFOM

- HFOM : Accuracy measure assuming that all satellites are operating correctly

- HPL : Integrity measure. Positional data within this limit with high degree of certainty (10^{-7}/ flight hour)
  - » Even if a satellite gives false range data
  - » Based on GPS receiver ability to detect satellite false range data given
    - – Satellite geometry
    - – RAIM algorithm capability
    - – Assumption SA on/off
    - – WAAS signal received
    - – Geo satellite received

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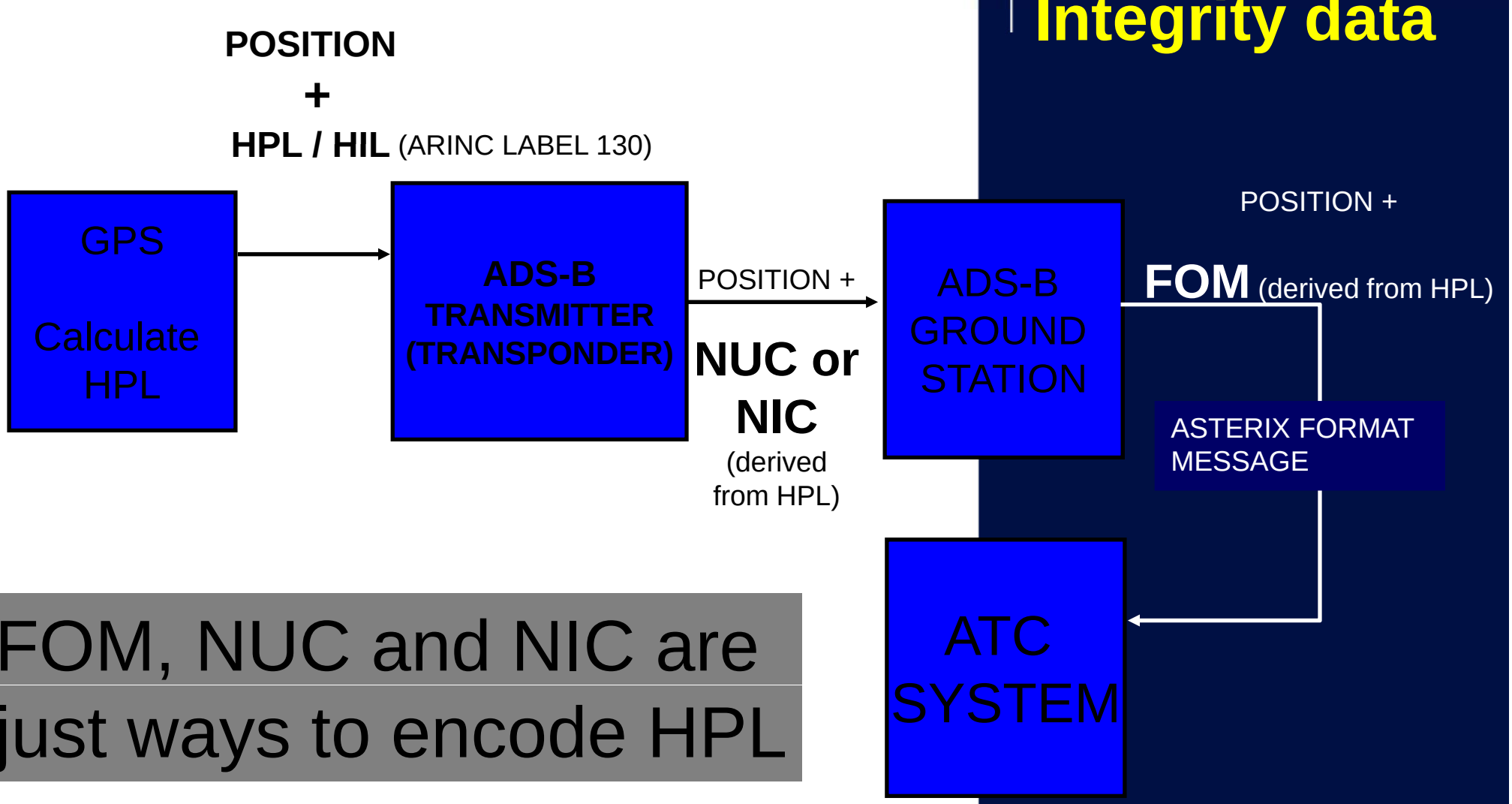
Integrity data



FOM, NUC and NIC are just ways to encode HPL

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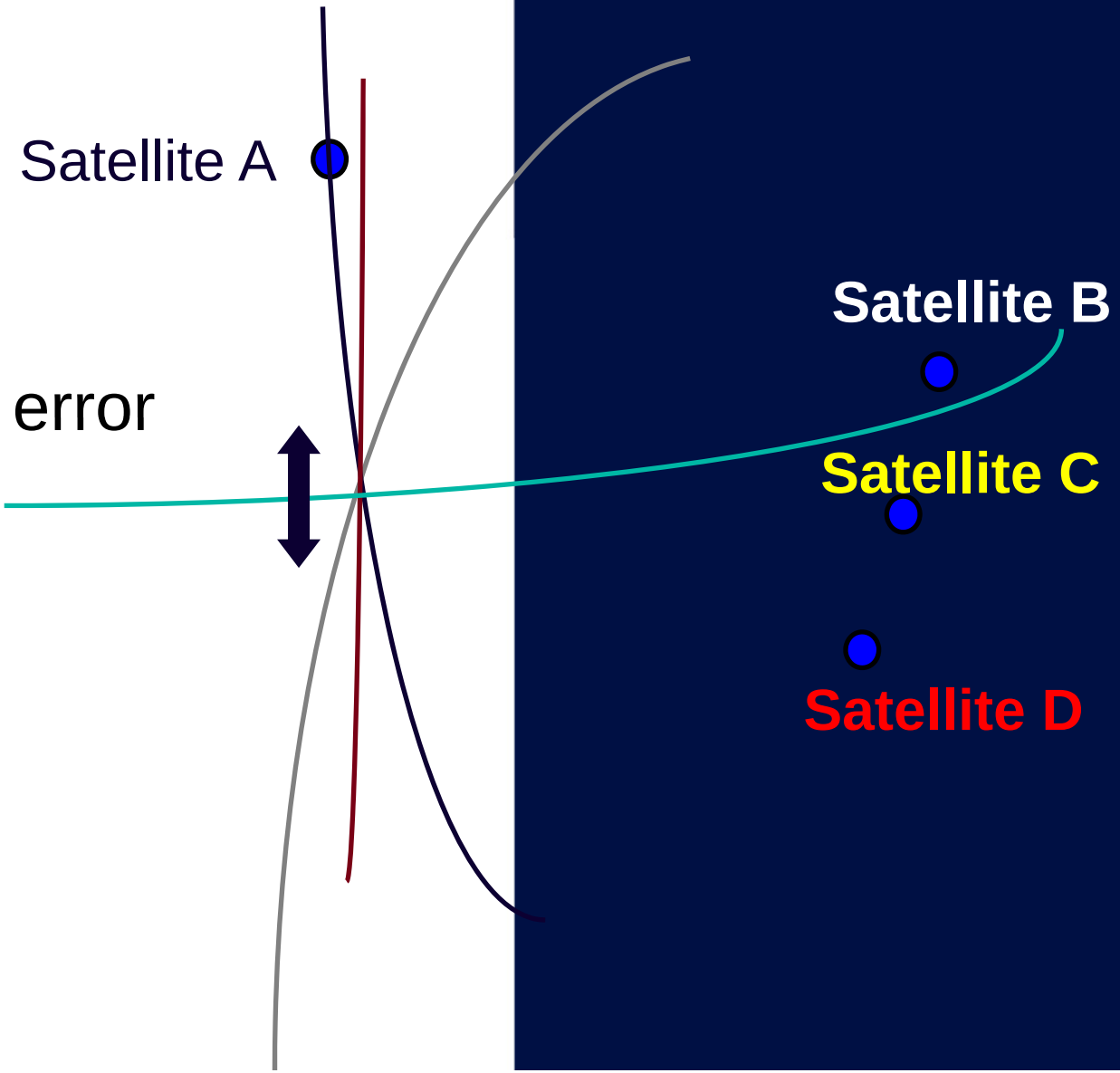
- Good accuracy
- Poor ability to detect error on Satellite A
- Poor HPL



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CRITICAL PREVIOUS APANPIRG DECISIONS

- Adopted Mode S as the interoperable standard
  - » DO260 accepted till 2020
  - » Acknowledging DO260A/B etc in future
- Mandates to be published asap – target 2010
- Mandate applicability with adequate time to equip after 2012
- Considerable ADS-B Related ADS-B Guidance material published

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Questions ?

- More details on Airservices Website
http://www.airservicesaustralia.com

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Reference Material

Task Force Meetings

http://www.icao.or.th/meetings/2007/adsb_adsb_tf6/index.html

http://www.icao.or.th/meetings/2006/ADSB_ADSBTF5/index.html

MATERIAL from Task Force

Strategy for the Provision of Navigation Services in the Asia/Pacific Region *Adopted by APANPIRG/18, 9/2007*

- *Strategy for the Implementation of GNSS Navigation Capability in the Asia/Pacific Region* *Adopted by APANPIRG/18, 9/2007*
- *Strategy for the Implementation of Surveillance Systems in the Asia/Pacific Region* *Adopted by APANPIRG/18, 9/2007*
- *Baseline ADS-B Service Performance Parameters* *Adopted by APANPIRG/18 – 9/ 2007*
- *ADS-B Implementation and Operations Guidance Document (AIGD)* *Edition 3.0 – 9/2007*
- *Multilateration (MLAT) Concept of Use* *Edition 1.0 – 9/2007*
- *Guidance Material on Comparison of Surveillance Technologies (GMST)* *Edition 1.0 9/ 2007*