ADS-B Introduction

Bangkok
March 2005

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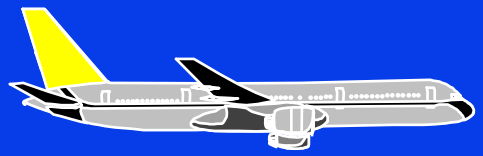
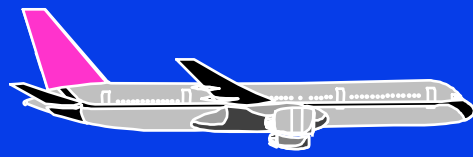
Airservices Australia

PART 1 : ATC SURVEILLANCE

- Surveillance types including ADS-B
- Air to Ground ADS-B
- Air-Air ADS-B
- ICAO and ADS-B

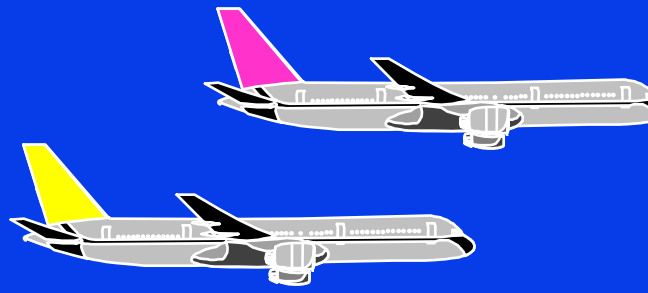
Procedural “Surveillance” (Dependent)





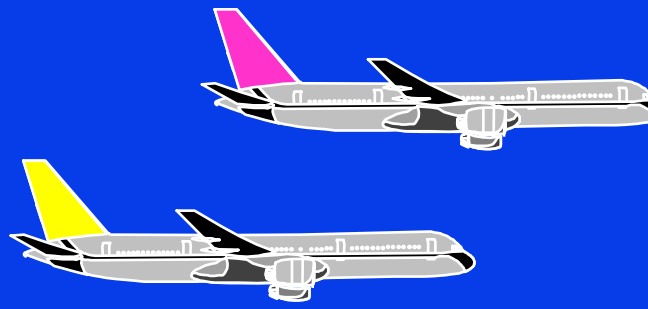
- Pilots report their position
  - Using a voice channel (HF, VHF)
  - Slow, cumbersome
  - Exposed to human error
  - Broadcast : Everyone “on frequency” hears it
- Procedures and standards maintain safety
- A form of dependant surveillance
  - We rely on the pilot/aircraft navigation capability

Primary Radar Surveillance (Independent)



- Radar measures position of aircraft
  - in range & azimuth
- Moderate update, accurate
  - Allows smaller separation standards
- Detects non co-operative targets
- Typically used in busy terminal areas

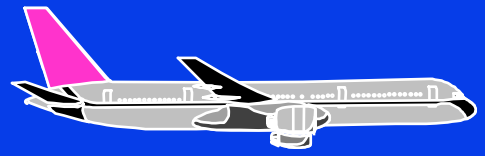
Secondary Radar Surveillance (Co-operative)

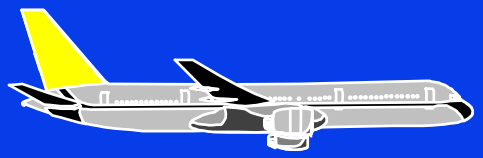


- Radar measures position of aircraft
  - in range & azimuth
  - but relies on cooperation of aircraft to reply
- High update, more accurate
- Allows addition of Safety alerts
- Depends on transponder to downlink altitude
  - Altitude data is “dependent” surveillance
  - datalink has no error check
- “SSR only” typically used enroute

Automatic Dependent Surveillance

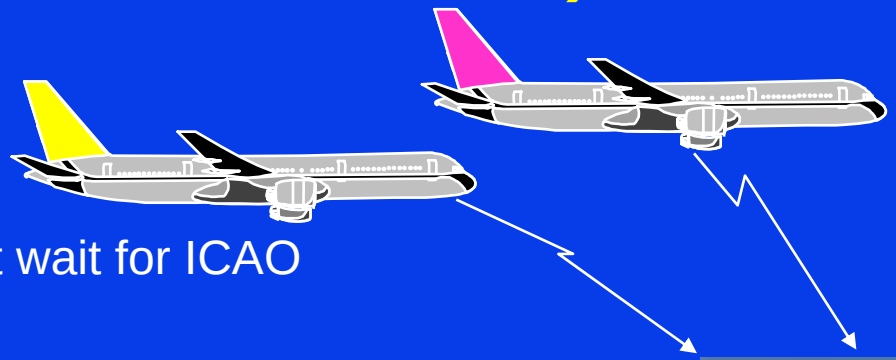
The aircraft measures its own position





- ***A**utomatic*
  - no pilot input required
  - No interrogation from ground
- ***D**ependent*
  - extremely accurate position and velocity vector from aircraft (eg GPS)
- ***S**urveillance*
  - aircraft position, altitude, velocity vector, + . . .

ADS-A (ADS-C Contract)



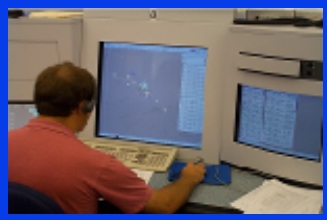
FANS1/A Equipment in “big” aircraft
- Expensive avionics
- Not ICAO defined. Asia/Pacific didn’t wait for ICAO

ATN & ICAO ADS-C
- Expensive avionics
- Limited availability

SITA / ARINC

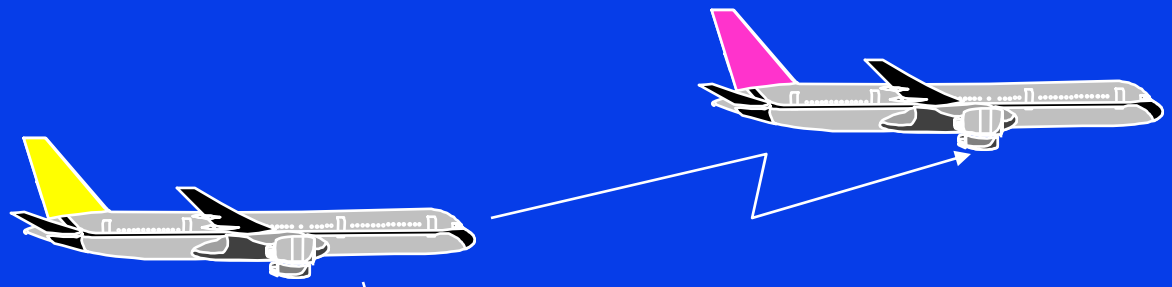
Uses satellite and VHF datalinks

Provides automatic, accurate routine reports
- Slow update rate ~ in minutes
- Allows exception reporting & supports safety alerts
- Reports are invisible to other aircraft



ATC system defines update message rate

ADS-B (Broadcast)



Typically broadcast 2/second

- ***A**utomatic*
  - no pilot input required
  - No interrogation from ground
- ***D**ependent*
  - extremely accurate positio and velocity vector from aircraft (eg GPS)
- ***S**urveillance*
  - aircraft position, altitude, velocity vector, + . . .
- ***B**roadcast*
  - any ground station or aircraft can monitor

ADS-B Functions

APPLICATIONS supported by ADS-B

ADS-B core applications		Optional/Ancillary
ATC Surveillance	Airborne surveillance	Broadcast services
- Separation	- Cockpit display (CDTI)	- TIS (Traffic Info Service)
- Safety nets	- In trail climb	- FIS (Flight info service)
- Traffic info	- Delegated separation	

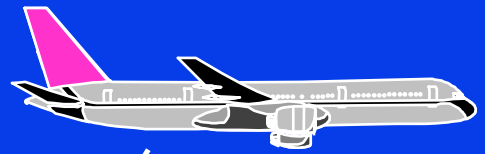
International "standardised" DATALINKS

VDL Mode 4 | ModeS | UAT

Ground systems

Automatic Dependent Surveillance Broadcast "Out"

"ADS-B OUT"

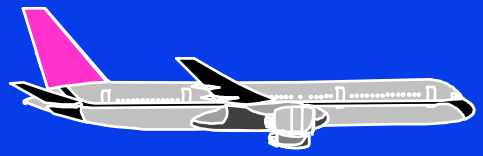


POSITION, ALTITUDE, IDENTITY(CALLSIGN), VELOCITY VECTOR, VERTICAL RATE

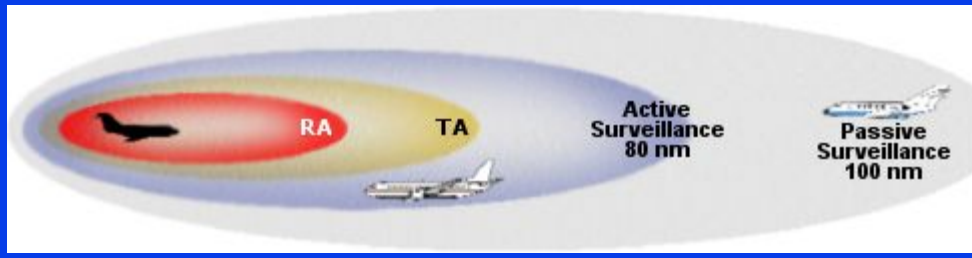
pically
oadcast 2 /second

ADS-B Ground station

ADS-B "IN"



- Display on TCAS or other display
- Longer range than TCAS
- Can include velocity vector & identi



Enhanced "see & avoid" Air-Air Surveillance

- Display on MFD or PDA
- 1090Rx

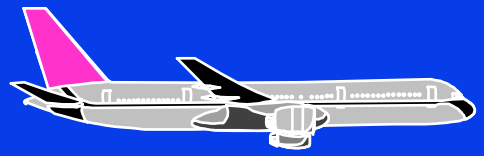
PART 1 : ATC SURVEILLANCE

- Surveillance types including ADS-B
- Air to Ground ADS-B
- Air-Air ADS-B
- ICAO and ADS-B

European Joint Coordination Board PACKAGE 1

- Five **Ground Surveillance** applications
  - ATC surveillance for en-route airspace (ADS-B-ACC);
  - ATC surveillance in terminal areas (ADS-B-TMA);
  - ATC surveillance in non-radar areas (ADS-B-NRA);
  - Airport surface surveillance (ADS-B-APT); and
  - Aircraft derived data for ground tools (ADS-B-ADD).

Automatic Dependent Surveillance Broadcast



ADS-B OUT

DOWNLINK MESSAGES

pically
oadcast 2 / second

ASTERIX DATA FORMAT

ADS-B Ground station

Asterix Cat 21 Messages

Adobe Acrobat Document

EUROCONTROL STANDARD DOCUMENT

FOR

SURVEILLANCE DATA EXCHANGE

Part 12 : Category 021

ADS-B Messages

SUR.ET1.ST05.2000-STD-12-01

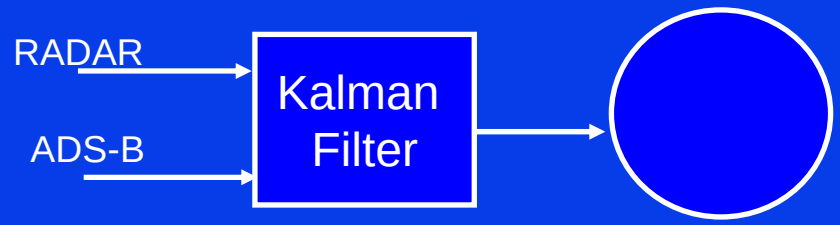
Edition	:	0.23
Edition Date	:	November 2003
Status	:	Working Draft
Class	:	General Public

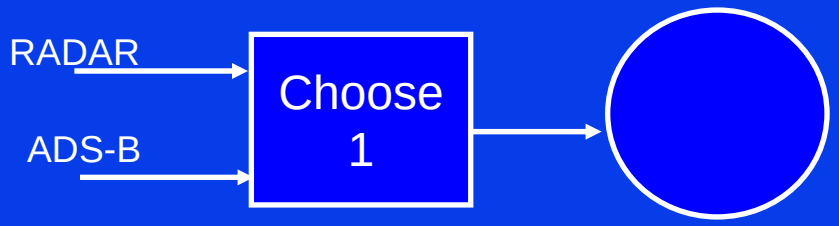
Table 1 - Data Items of Category 021

Data Item Reference Number	Description	Resolution
I021/010	Data Source Identification	N.A.
I021/020	Emitter Category	N.A.
I021/030	Time of Day	1/128 s
I021/032	Time of Day Accuracy	1/256 s
I021/040	Target Report Descriptor	N.A.
I021/080	Target Address	N.A.
I021/090	Figure of Merit	N.A.
I021/095	Velocity Accuracy	N.A.
I021/110	Trajectory Intent	N.A.
I021/130	Position in WGS-84 co-ordinates	$180/2^{23}$ °
I021/140	Geometric Altitude	6.25 ft
I021/145	Flight Level	¼ FL
I021/146	Intermediate State Selected Altitude	25 ft
I021/148	Final State Selected Altitude	25 ft
I021/150	Air Speed	N.A.
I021/151	True Air Speed	N.A.
I021/152	Magnetic Heading	$360/2^{16}$ °
I021/155	Barometric Vertical Rate	6.25 ft / min
I021/157	Geometric Vertical Rate	6.25 ft / min
I021/160	Ground Vector	N.A.
I021/165	Rate of Turn	¼ °/s
I021/170	Target Identification	N.A.
I021/200	Target Status	N.A.
I021/210	Link Technology Indicator	N.A.
I021/220	Met Report	N.A.
I021/230	Roll Angle	0.01 deg

ATC System able to process ADS-B

- Two methods:
  - Integrated tracker
    - ✈Meld ADS-B and Radar data
  - Priority tracks
    - ✈Display ADS-B or Radar data





Automatic Dependent Surveillance Broadcast

ADS-B ground stations are simple and economical

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

Cost Comparison

Maintenance
Power
Site space
Building
Road
Environmental
Rotating machinery

RADAR
~ $1M - $4M USD

AIRSERVICES AUSTRALIA

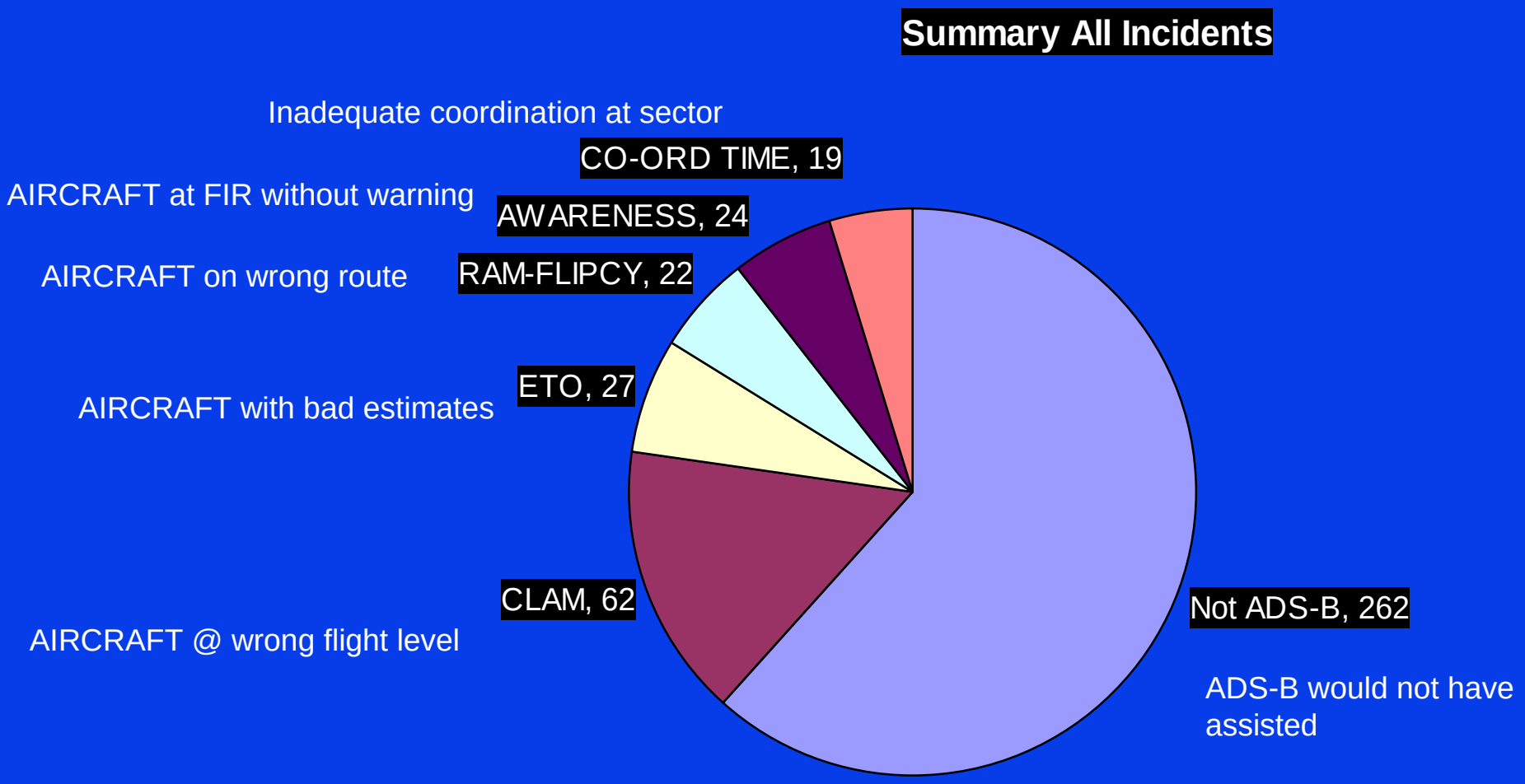
ADS-B UAP
Airline benefits

- Safety
  - ATC situational awareness
  - ATC safety nets
  - SAR
  - FIR boundary safety

- Operational flexibility benefit
  - Higher Probability of clearance request
  - Optimum route/ level
  - Strategic enabler for User preferred route

- Operational control/ fleet management

Incident review



ATM Discontinuities

- 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 may provide inexpensive means to share data

Main downlink data

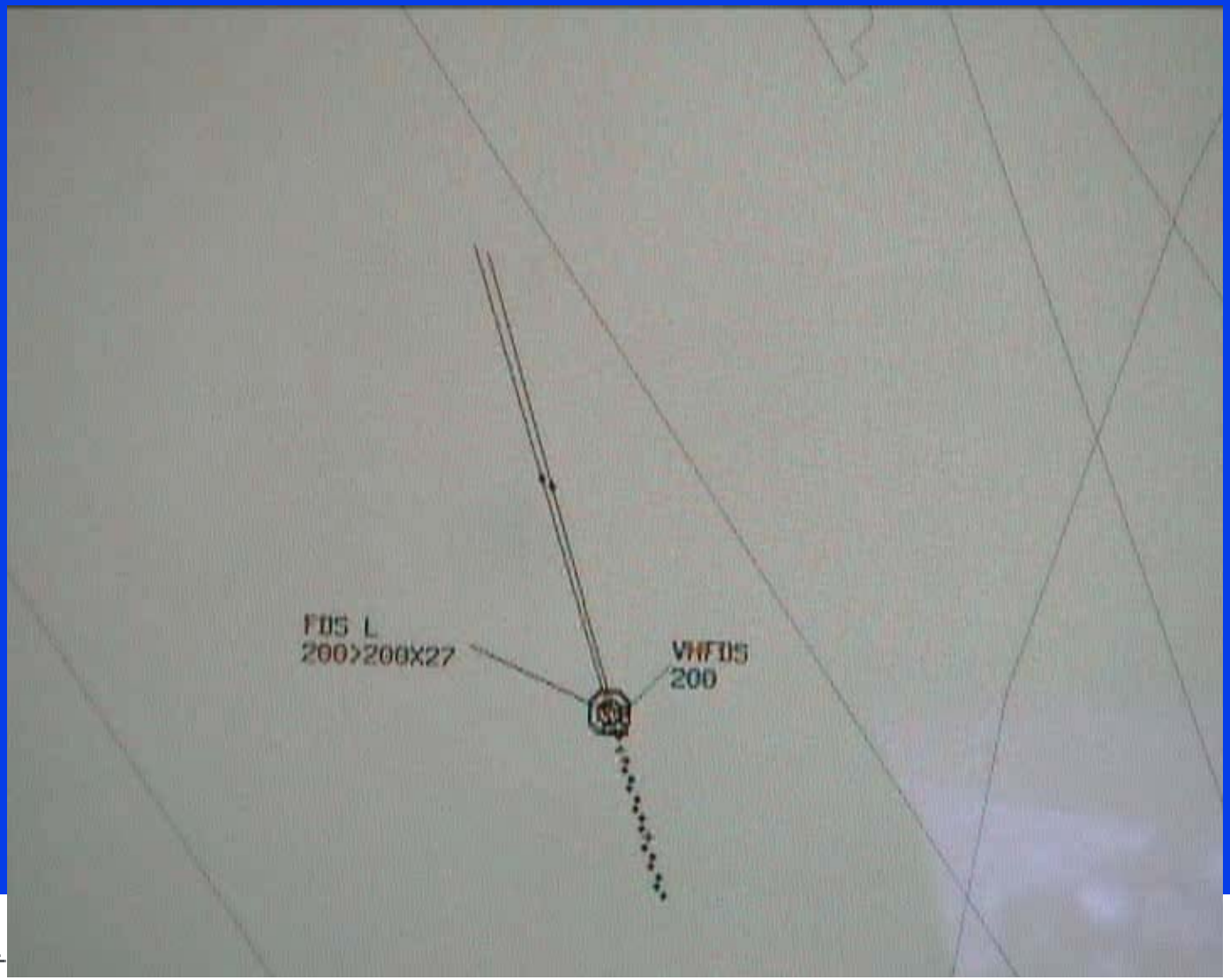
- Positional data downlink
- Integrity data downlink
- Barometric altitude data downlink
- ICAO airframe unique 24 bit code
- Flight identity downlink
- Velocity vector data

Other useful data

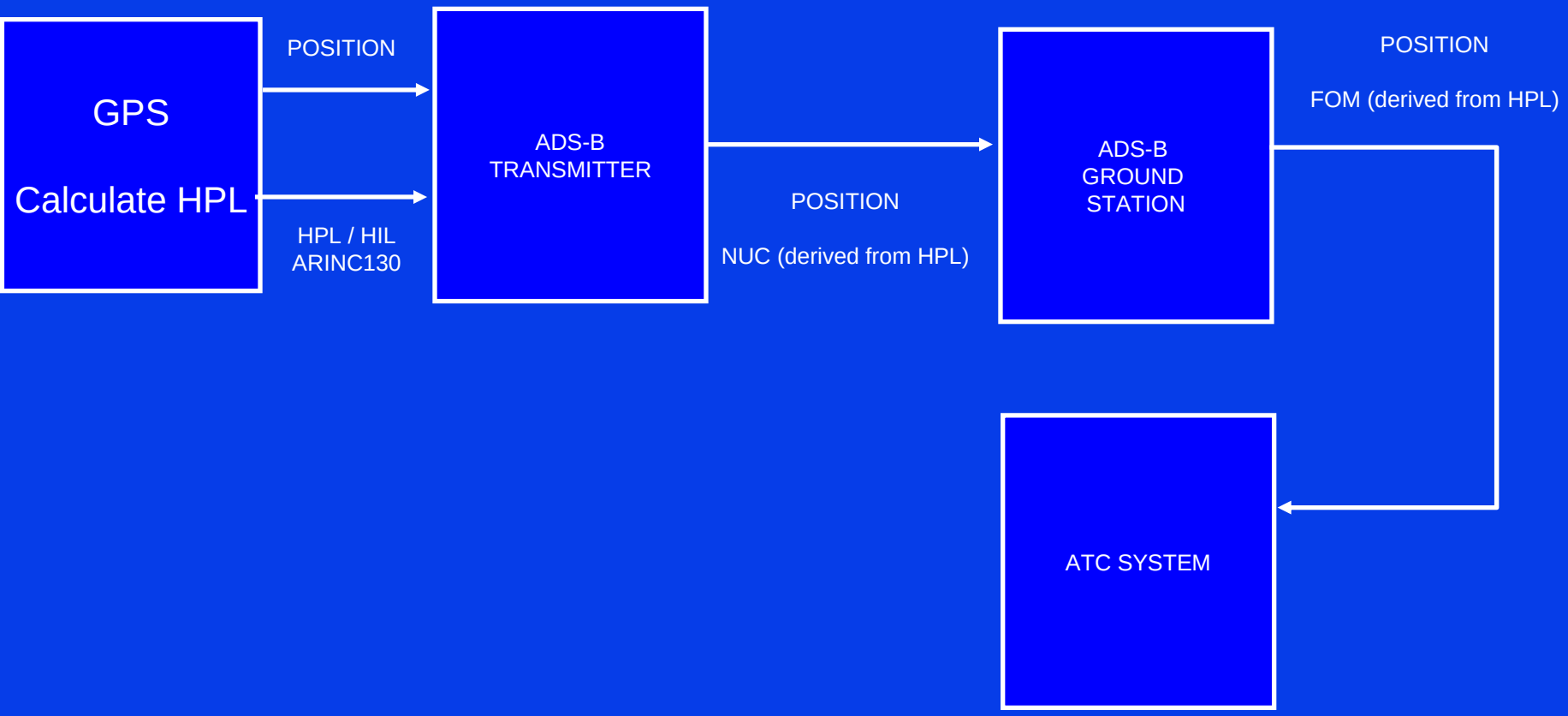
- Geometric altitude
- Indicated speed (wind)
- Status data (emergencies, aircraft type category)
- Trajectory Intent data
  - not yet well enough defined
  - Not available outside FMS

ADS-B & Radar Velocity vectors

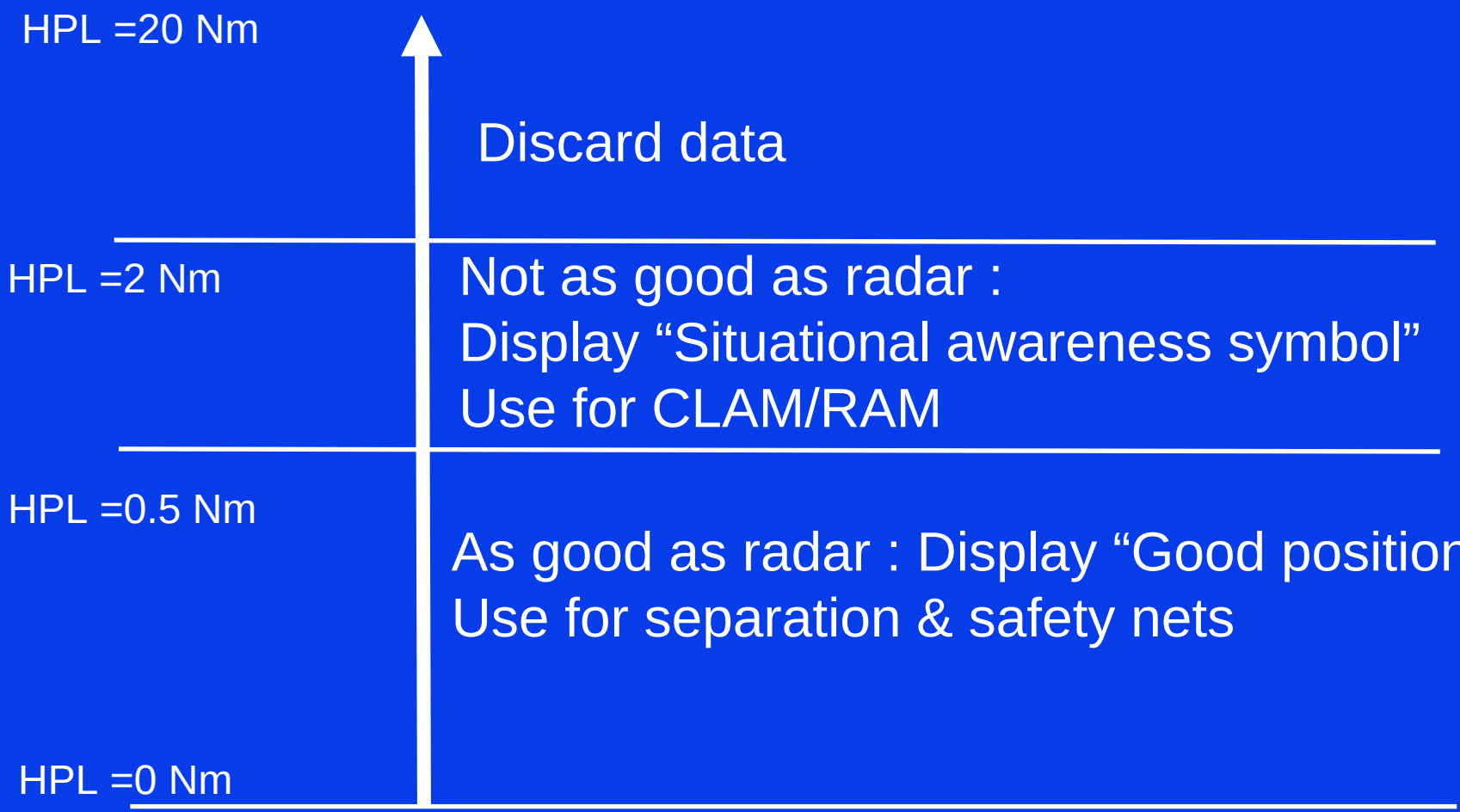
(B200 Sharp turn)



HPL



Data “quality”



Integrity data

rizontal Protection Limit (HPL)
orizontal Integrity Limit HIL)

INC Label 130

hat value of FOM/NUC/HPL
adequate for radar like
rveillance?

stralia to start with NUC=5

C= Navigational Uncertainty Category
metimes message "TYPE" is used

Table 2-11: "TYPE" Subfield Code Definitions (DF = 17 or 18)

Type Code	Format	Horizontal Protection Limit, HPL	95% Containment Radius, μ and ν, On Horizontal and Vertical Position Error	Altitude Type
0	No Position Information			Baro Altitude or No Altitude Information
1	Identification (Category Set D)			*Not Applicable*
2	Identification (Category Set C)			*Not Applicable*
3	Identification (Category Set B)			*Not Applicable*
4	Identification (Category Set A)			*Not Applicable*
5	Surface Position	HPL < 7.5 m	μ < 3 m	No Altitude Information
6	Surface Position	HPL < 25 m	3 m ≤ μ < 10 m	No Altitude Information
7	Surface Position	HPL < 185.2 m (0.1 NM)	10 m ≤ μ < 92.6 m (0.05 NM)	No Altitude Information
8	Surface Position	HPL ≥ 185.2 m (0.1 NM)	(0.05 NM) 92.6 m ≤ μ	No Altitude Information
9	Airborne Position	HPL < 7.5 m	μ < 3 m	Baro Altitude
10	Airborne Position	7.5 m ≤ HPL < 25 m	3 m ≤ μ < 10 m	Baro Altitude
11	Airborne Position	25 m ≤ HPL < 185.2 m (0.1 NM)	10 m ≤ μ < 92.6 m (0.05 NM)	Baro Altitude
12	Airborne Position	185.2 m (0.1 NM) ≤ HPL < 370.4 m (0.2 NM)	92.6 m (0.05 NM) ≤ μ < 185.2 m (0.1 NM)	Baro Altitude
13	Airborne Position	380.4 m (0.2 NM) ≤ HPL < 926 m (0.5 NM)	185.2 m (0.1 NM) ≤ μ < 463 m (0.25 NM)	Baro Altitude
14	Airborne Position	926 m (0.5 NM) ≤ HPL < 1852 m (1.0 NM)	463 m (0.25 NM) ≤ μ < 926 m (0.5 NM)	Baro Altitude
15	Airborne Position	1852 m (1.0 NM) ≤ HPL < 3704 m (2.0 NM)	926 m (0.5 NM) ≤ μ < 1.852 km (1.0 NM)	Baro Altitude
16	Airborne Position	7.704 km (2.0 NM) ≤ HPL < 18.52 km (10 NM)	1.852 km (1.0 NM) ≤ μ < 9.26 km (5.0 NM)	Baro Altitude
17	Airborne Position	18.52 km (10 NM) ≤ HPL < 37.04 km (20 NM)	9.26 km (5.0 NM) ≤ μ < 18.52 km (10.0 NM)	Baro Altitude
18	Airborne Position	HPL ≥ 37.04 km (20 NM)	18.52 km (10.0 NM) ≤ μ	Baro Altitude
19	Airborne Velocity	*Not Applicable*	*Not Applicable*	*Difference between "Baro Altitude" and "GNSS Height (HAE)"*
20	Airborne Position	HPL <7.5 m	μ < 3 m and ν < 4 m	GNSS Height (HAE)
21	Airborne Position	HPL <25 m	μ < 10 m and ν < 15 m	GNSS Height (HAE)
22	Airborne Position	HPL ≥25 m	μ ≥ 10 m or ν ≥15 m	GNSS Height (HAE)
23	Reserved for Test Purposes			

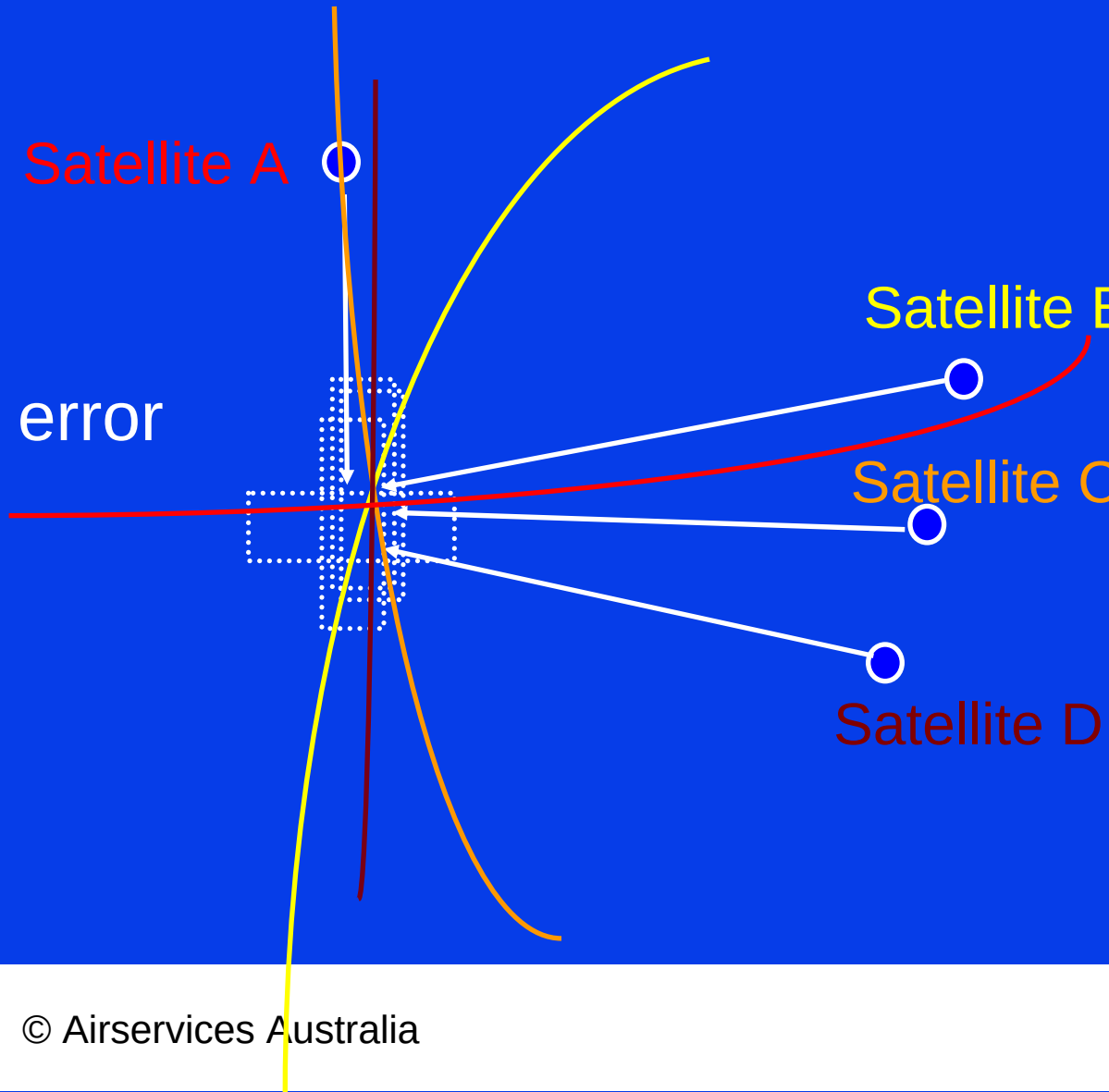
AIRSERVICES AUSTRALIA

HPL / HFOM

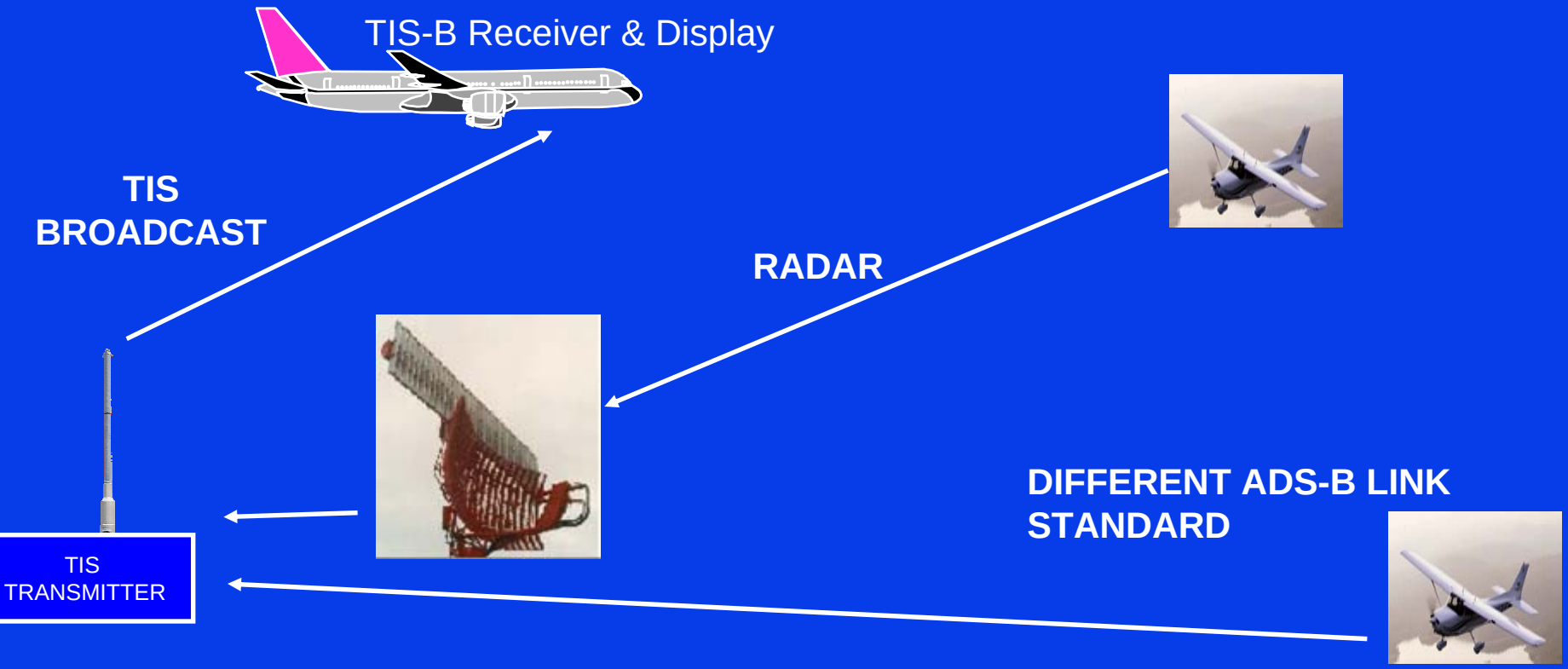
- HFOM : Accuracy measure assuming that all satellites are operating correctly
- HPL : Integrity measure. Positional data within this limit with high degree of certainty (10^{-7}/ flight hour)
  - Even if a satellite gives false range data
  - Based on GPS receiver ability to detect satellite false range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

Good HDOP / HFOM – Poor HPL

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



Traffic Information Service Broadcast (TIS-B)



A service provided by ground stations, broadcasting information relating to aircraft based on surveillance carried out by ground systems, using ADS-B signals, formats and protocols, compatible with ADS-B receiving equipment.

Draft ICAO ASAS Circular

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- Air-Air ADS-B
- ICAO and ADS-B

European Joint Coordination Board PACKAGE 1

Seven **Air-Air Surveillance** applications

- Enhanced traffic situational awareness on the airport surface (ATSA-SURF);
- Enhanced traffic situational awareness during flight operations (ATSA-AIRB);
- Enhanced visual acquisition for see & avoid (ATSA-S&A);
- Enhanced successive visual approaches (ATSA-SVA);
- Enhanced sequencing and merging operations (ASPA-S&M);
- In-trail procedure in oceanic airspace (ASPA-ITP); and
- Enhanced crossing and passing operations (ASPA-C&P).

BAe Systems
Pass Behind application

UPS Fleet Status
Successive visual approaches

32 B-767—100%

73 B-757—97%

11 A300-600—1090 Squit Only

PART 1 : ATC SURVEILLANCE

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- Air-Air ADS-B
- ICAO and ADS-B

ANC11 Supports ADS-B

AN-Conf/11-WP/190

1-12 Report on Agenda Item 1

Recommendation 1/7 — Ground and airborne automatic dependent surveillance-broadcast (ADS-B) applications for global interoperability

That ICAO and States:

a) recognize ADS-B as an enabler of the global ATM operational concept bringing substantial safety and capacity benefits;

b) support the cost-effective early implementation of packages of ground and airborne ADS-B applications, noting the early achievable benefits from new ATM applications; and

c) ensure that implementation of ADS-B is harmonized, compatible and interoperable with respect to operational procedures, supporting data link and ATM applications.

ICAO PANELS

- OPLINK : Has developed an ADS-B Conops
  - Endorsed by ANC11
- SASP : Is developing 5Nm Separation standards
- SCRSP : Continues to refine ModeS standards
- ACP : Has defined VDL Mode4 and is developing UAT standards

Adobe Acrobat Document

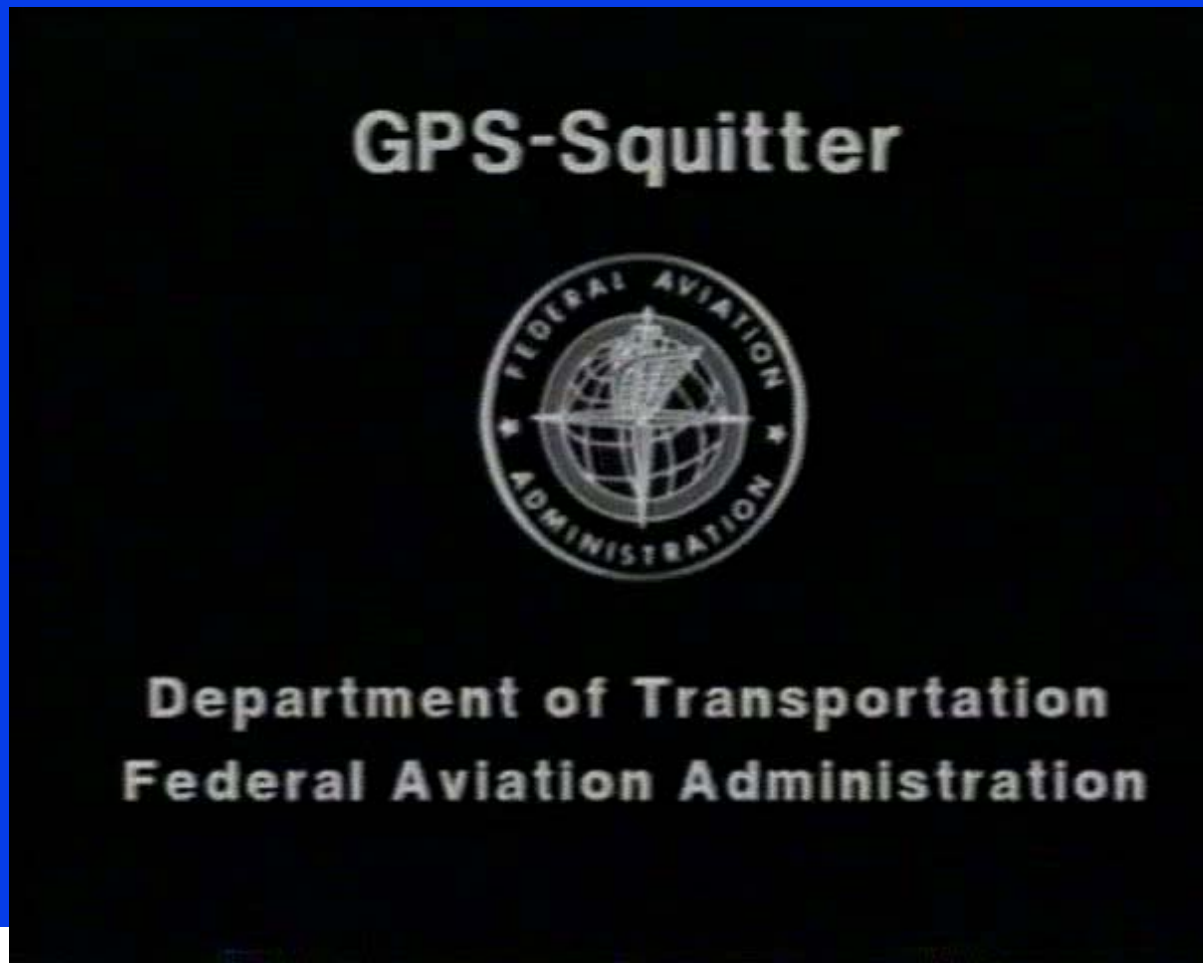
Worldwide ADS-B link status

- FAA has chosen Mode S for Air Transport aircraft and UAT for "low end GA"
- Eurocontrol has supported Mode S as the interoperable link for the near term. Europe expects an additional link to be required.
- Eurocontrol and FAA are co-operating in Requirements Focus Group (RFG) developing application descriptions and other documentation.
  - Independent of link
  - Expectation is to deliver this to ICAO

Its time to deploy “ADS-B out”

me for talking about
nks is over

s time to get
e benefits.



PART 2 : 1090ES & Mode S Technology

- Radar, ModeS and ADS-B review
- ADS-B messages
- Avionics standards
- Fitment
- Ground system
- Multilat synergy
- Performance

SSR background

AIRCRAFT

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

ModeA, C interrogations

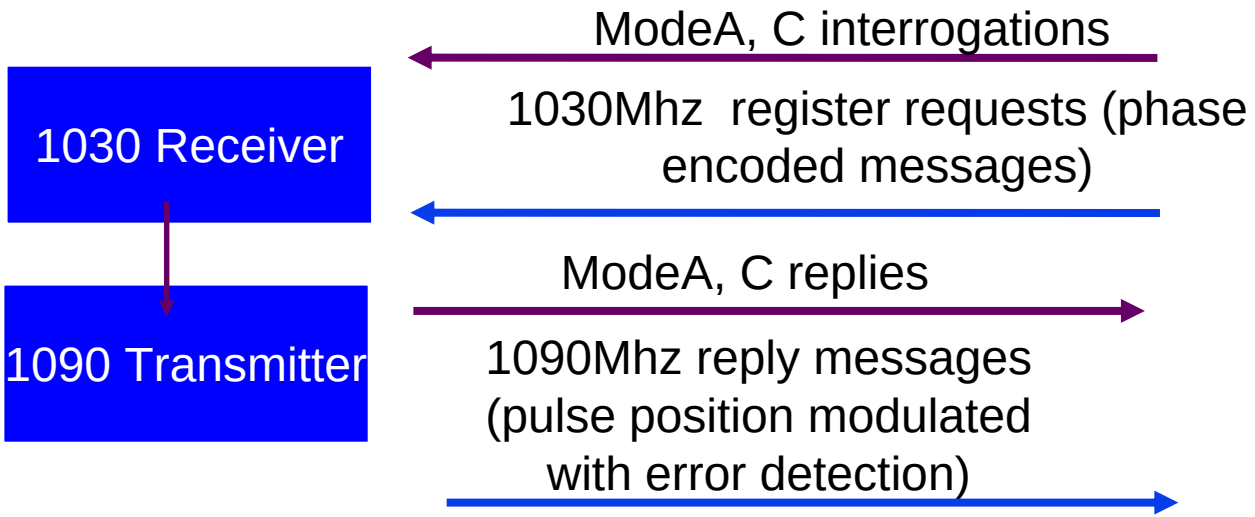
1030 Receiver

1090 Transmitter

ModeA, C replies

1090Mhz reply messages 12 pulses
(no error detection)

MODE S background



Readout :
“Registers”

TCAS background

1030Mhz Interrogations 3 pulses

1030 Receiver

1030Mhz register requests (phase encoded messages)

ansmit DF11

1090Mhz reply pulses

1090 Transmitter

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

ceive ModeC replies

ceive DF11

ceive DF0

1090 Receiver

TCAS LOGIC & Display

1030 Transmitter

Mode C interrogate
Mode S interrogate (UF0)

Enhanced & Elementary Surveillance

ATA to FILL the REGISTERS

allsign panel

PS Receiver

FMS

Air Data Computer

1030 Receiver

1090 Transmitter

1030Mhz Interrogations 3 pulses

1030Mhz register requests (phase encoded messages)

1090Mhz reply pulses

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

Readout :
Callsign
Bank angle
Selected level
Airspeed
Heading

ADS-B background

GPS Receiver

1030 Receiver

1090 Transmitter

ANSMIT
F17/18 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

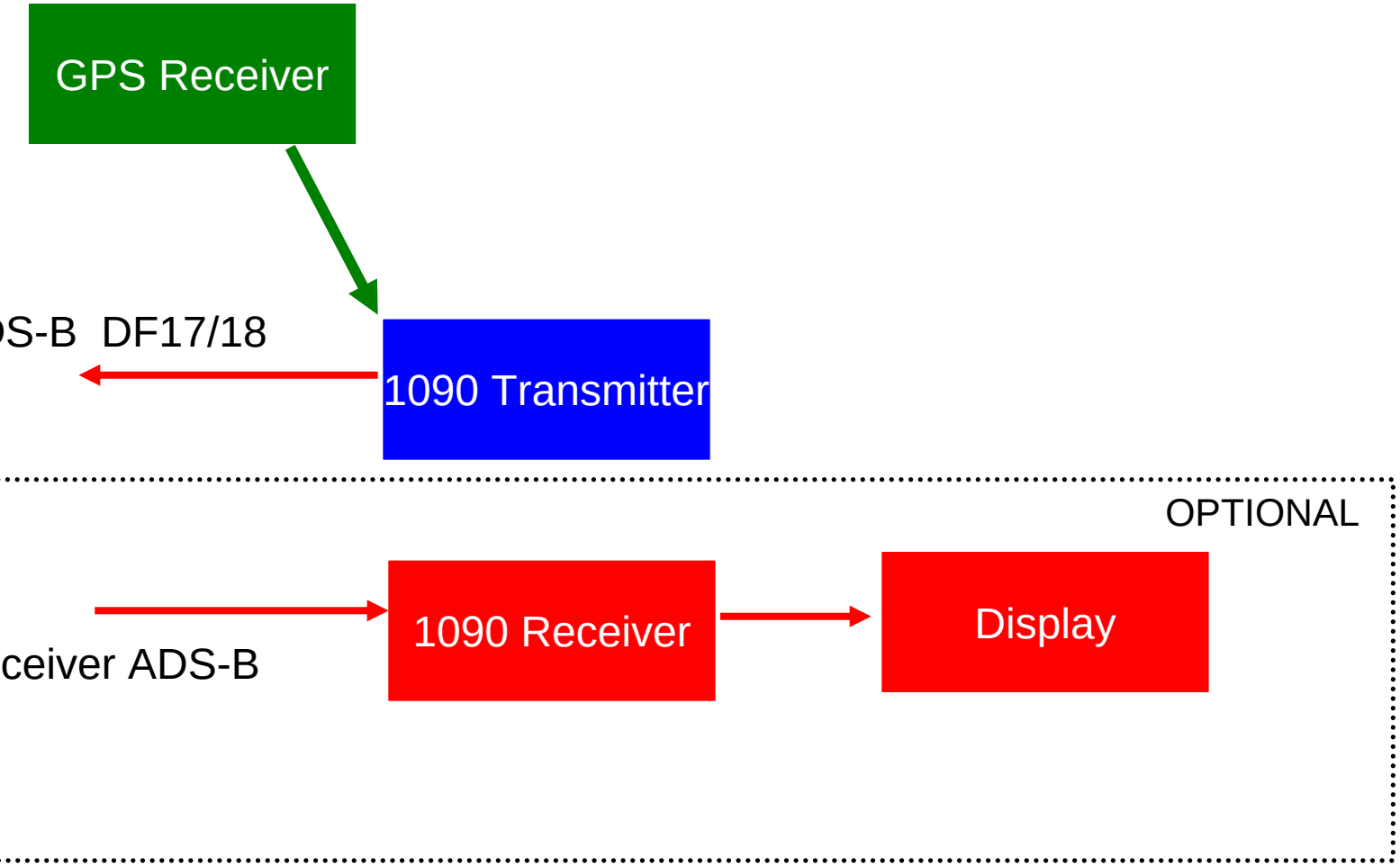
TCAS LOGIC & Display

ceive
F17,DF18
DS-B
display

1030 Transmitter

Mode C interrogate other aircraft & Mode S encounter

ADS-B simplified



PART 2 : 1090ES & Mode S Technology

- Radar, ModeS and ADS-B review
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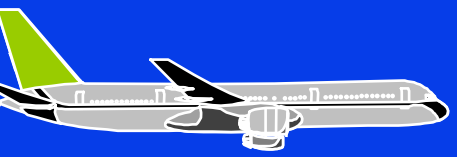
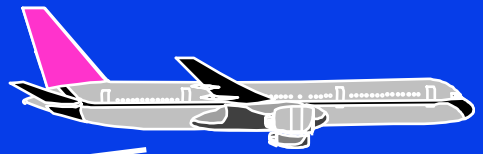
- Ground system
- Multilat synergy
- Performance

Mode S Transponder & ADS-B





TCAS

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

CONTROL	24 bit AIRCRAFT ADDRESS	PARITY

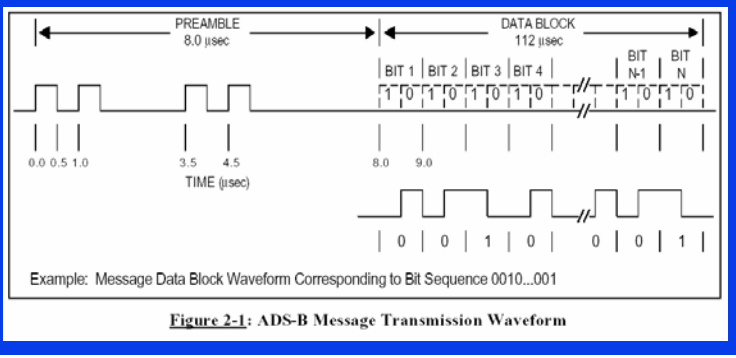


Figure 2-1: ADS-B Message Transmission Waveform

ADS-B

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

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

SSR MODE S EXTENDED LENGTH MESSAGE

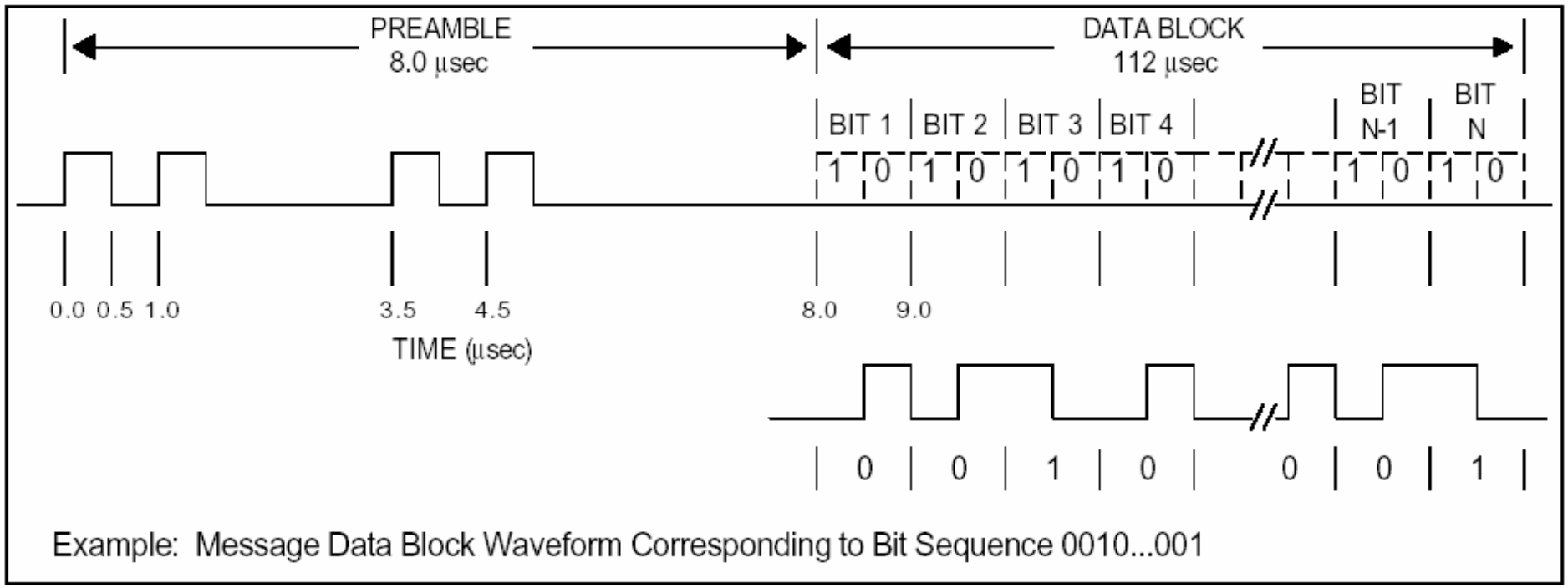


Figure 2-1: ADS-B Message Transmission Waveform

MODE S EXTENDED SQUITTER

SHORT SQUITTER	CONTROL (8)	MODE S ADDRESS (24)	PARITY (24)	56 BITS
LONG SQUITTER	CONTROL (8)	MODE S ADDRESS (24)	ADS-B MESSAGE (56 BITS)	PARITY	112 BITS

SQUITTER TYPE									BROADCAST INTERVALS
AIRBORNE POSITION	Type (5)	Status/Ant (2+1)	Altitude (12)			T (1)	CPR (1)	Lat Long (34)	0.5s
AIRBORNE VELOCITY	Type (5)	Sub-type (3)	Intent (1)	IFR (1)	NUC (3)	Horizontal Velocity (22)	Vertical Velocity (11)	Turn (2)	Diff Baro Alt(8)	0.5s
SURFACE POSITION	Type (5)	Movement (7)	Status (1)	Heading (7)		T (1)	CPR (1)	Lat Long (34)	0.5s or 5s
AIRCRAFT IDENTIFIC'N	Type (5)	A/C type (3)	8 Character Aircraft Callsign (48 bits)						5s or 10s* (* if stationary)
EVENT DRIVEN	Type (5)	Sub-type (3)	Event Data (48 bits)						As required

PART 2 : 1090ES & Mode S Technology

- Radar, ModeS and ADS-B review
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- Performance

Standards for Mode S

- ICAO → Signals in Space
  - Annex 10 SARPS Amend 77

- AVIONICS & TEST STANDARDS
  - RTCA
    - → ADS-B MASPS DO242
    - → ADS-B MOPS 1090 DO260 & DO260A
    - → Mode S MOPS DO-181c include ADS-B

- AVIONICS & TEST STANDARDS
  - EUROCAE
    - → ED73A Mode S MOPS
    - → ED102 ADS-B for 1090Mhz

- FORM/FIT STANDARDS
  - AEEC
    - → ARINC 718A

- FORM/FIT STANDARDS
  - EUROCAE
    - → ED86

- **FAA (Regulator)**
  - → TSO C112
  - → TSO C116 DRAFT

- JAA (Regulator)
  - → JTSO 2C112

- CASA (Regulator)
  - → ATSO C1004 ModeAC + ADS_B
  - → ATSO C1005 ADS-B alone

ICAO Annex 10 Amendment 77

2.3 EXTENDED SQUITTER FORMATS

section defines the formats and coding that shall be used for extended squitter ADS-B messages. When the extended squ
bility is implemented as an extended squitter/non-transponder device (ES/NT, Annex 10, Volume IV, 3.1.2.8.7), the conven
egister numbering shall not apply. The data content and the transmit times shall be the same as specified for the transpo

2.3.1 FORMAT TYPE CODES

format type code shall differentiate the Mode S extended squitter messages into several classes as specified in the follo
e:

"TYPE" Subfield Code Definitions (DF = 17 or 18)

pe de	*Format*	*Horizontal protection limit, (HPL)*	*95% Containment radius, μ and ν, on horizontal and vertical position error*	*Altitude type (2.3.2.4)*	*NUC*
0	No position information			Baro altitude or no altitude information	0
1	Identification (Category Set D)			*Not applicable*	
2	Identification (Category Set C)			*Not applicable*	
3	Identification (Category Set B)			*Not applicable*	
4	Identification (Category Set A)			*Not applicable*	
5	Surface position	HPL < 7.5 m	μ < 3 m	No altitude information	9
6	Surface position	HPL < 25 m	3 m < μ < 10 m	No altitude information	8

Anc11 Support Mode S for near term

AN-Conf/11-WP/202

7-12 Report on Agenda Item 7

7.4.5.5 On the basis of the above considerations with regard to potential near term ADS-B solutions, the meeting formulated the following Recommendation:

Recommendation 7/1 — Strategy for the near-term introduction of ADS-B

That States:

a) note that a common element in most of the approaches currently adopted for early implementation of ADS-B is the selection of the SSR Mode S extended squitter as the initial data link; and

b) take into account this common element to the extent possible in their national and regional implementation choices in order to facilitate global interoperability for the initial introduction of ADS-B.

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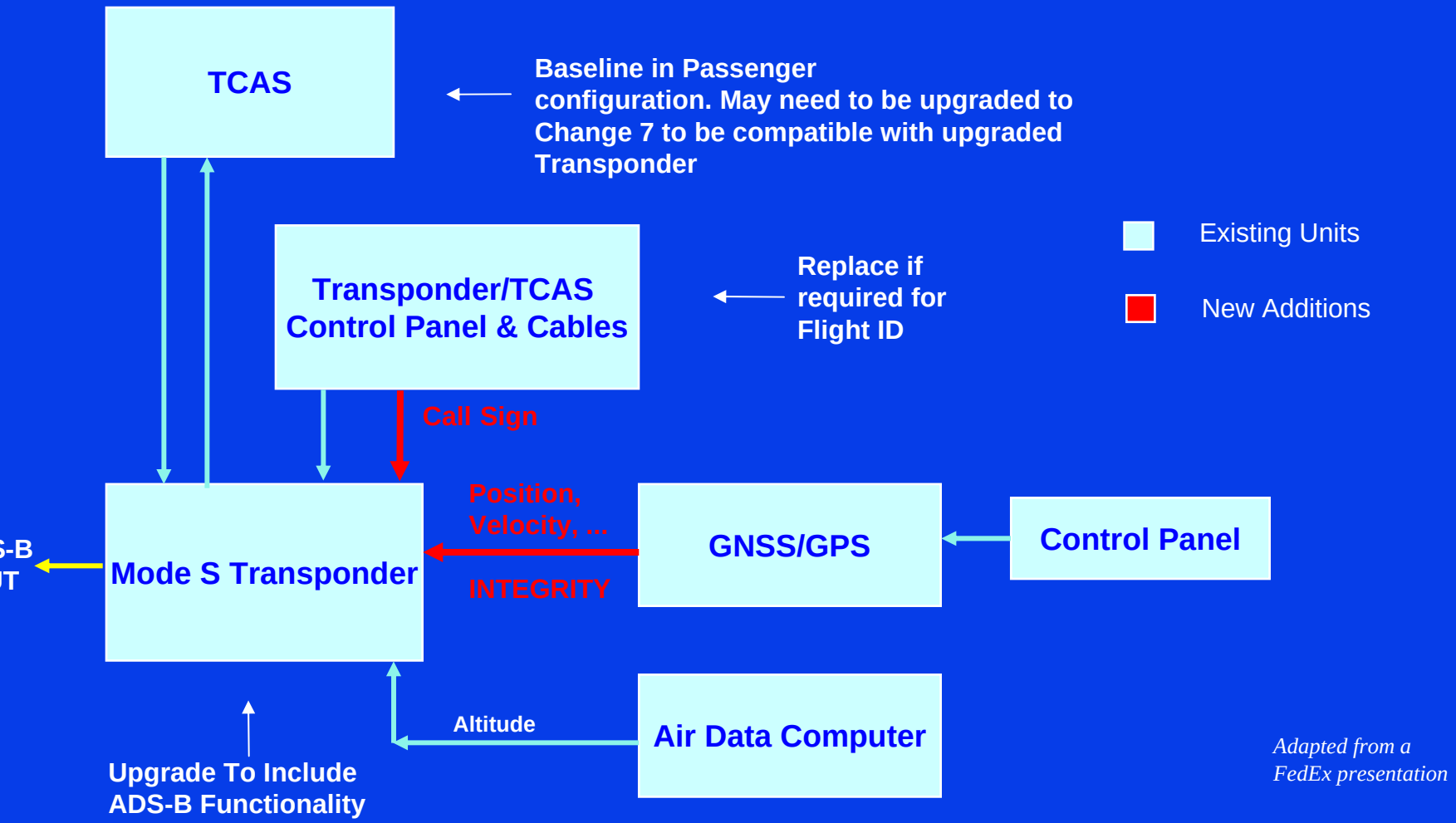
ADS-B Class B (ADS-B Out) Avionics Architecture



Adapted from a FedEx presentation

Airliner Mod Kit for “ADS-B out”

ansponder
oftware

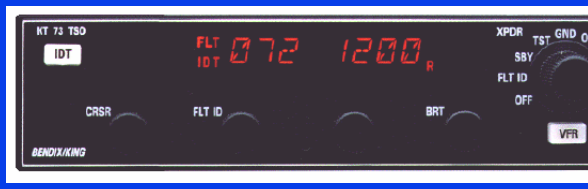
PS data bus

Don’t need cockpit displays for ADS-B out

Adapted from a FedEx presentation

Avionics – Available today

- Honeywell
  - Air Transport — TRA-67A
  - Business / GA — MST-67A & KT-73



Bendix-King KT-73

- Rockwell Collins
  - Air Transport — TPR-901
  - Business / GA — TDR-94/94D


Rockwell-Collins TDR-94D

- ACSS
  - Air Transport — XS-950
  - Business / GA — RCZ-852

- UPS-AT

Prices for Avionics

- Close to zero for new aircraft off the production line
  - Eg: Airbus, Boeing
  - BUT Bombardier, SAAB & Embrarer don't support it yet
- Expensive for old aircraft without GPS (eg B767)

- Cost of Service Bulletin from Boeing/Airbus depends on relationship. Low cost to Very high cost

European mandate

Adobe Acrobat Document

DFS Deutsche Flugsicherung

BUNDESREPUBLIK DEUTSCHLAND
FEDERAL REPUBLIC OF GERMANY

AIC IFR
AIC IFR 6
23 JAN 03

DFS Deutsche Flugsicherung GmbH (German Air Navigation Services)
Büro der Nachrichten für Luftfahrer (Aeronautical Publication Agency)
Am DFS-Campus 10 · 63225 Langen · Germany
Tel. + 49 (0) 6103 707 - 12 71/1272 · Fax + 49 (0) 6103 707 - 12 96
http://www.dfs-service.de · e-mail: buero.nfl@dfs.de

SSR-Mode S Elementary Surveillance (ELS)

1. GENERAL

1.1 The purpose of this Circular is to present comprehensive information on the current planning of the EUROCONTROL Member States and other States in the ICAO EUR Region concerning the requirements for the airborne carriage and operation of SSR Mode S equipment and more specifically the detailed requirements for the Mode S Elementary Surveillance functionality. It shall be read in conjunction with earlier State regulations concerning Mode S and ICAO Regional Supplementary Procedures Doc 7030, EUR Part 1. Additional material can be found in the Joint Aviation Authorities (JAA) Administrative and Guidance Material, Leaflet No. 13, Certification of Mode S Transponder Systems for Elementary Surveillance.

Airlines in Australia are equipping

Thank you Europe : for EHS, ELS mandate

- Qantas has committed to fit aircraft with ADS-B “out”
  - A330, A320, A380, B737, B747 (say >50% of fleet)
  - Jetstar expected fully fit 23 A320s

- Virgin Blue : 737-800s
  - Already has 15 transmitting
  - All future deliveries equipped

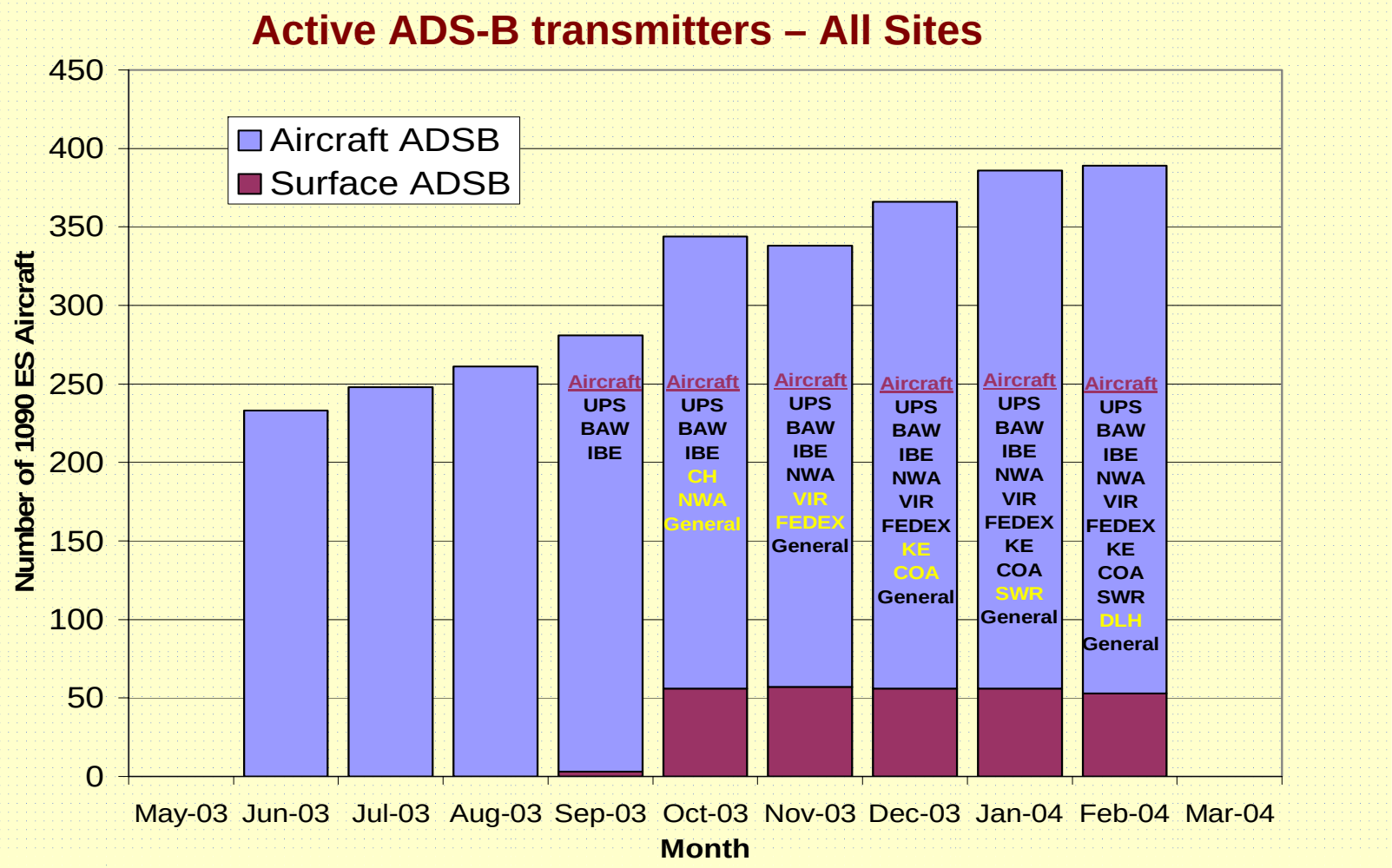
- Some already being detected by existing ADS-B Ground station
  - Airbus A330
  - Boeing 767, 777 and 737’s
  - Boeing 747’s detected

Transponders that meet standard ARINC718A

Policy

- Qantas group of airlines has expressed its support for the deployment of ADS-B as an ATC surveillance tool
- New jet aircraft received by Qantas will have an ADS-B capability and European requirements for “elementary” and “enhanced” SSR operation offer a convenient opportunity to retrofit the long haul fleet

The U.S. Population of ADS-B Equipped Aircraft is Growing



Graph courtesy of Dr. Wilson Felder, Director, Office of Technology Developme FAA

Navigation Strategy in Australia

- Transition to GNSS Primary Means
  - Large aircraft become FMS/ GPS/ IRS
  - Smaller aircraft use TSO146 navigators
- Decommission navaids but maintain a Backup network
  - About 50% of Navaids removed
  - Keep ILS
- Navaid Life Extension Project
  - That are part of backup network

New Generation GPS receivers
TSO 145/146

- New “WAAS” GPS engines
  - WAAS capability not required in many countries
  - No WAAS ground monitoring

- Australia expects CASA approval for only means because of”
  - SA off assumption :
    - ✈ Greater availability for a required integrity/accuracy
  - Fault detection & Exclusion (FDE)
    - ✈ Operation continues if faulty GPS ranging signal
  - HPL output to external systems (ADS-B)

Enormous Synergy between

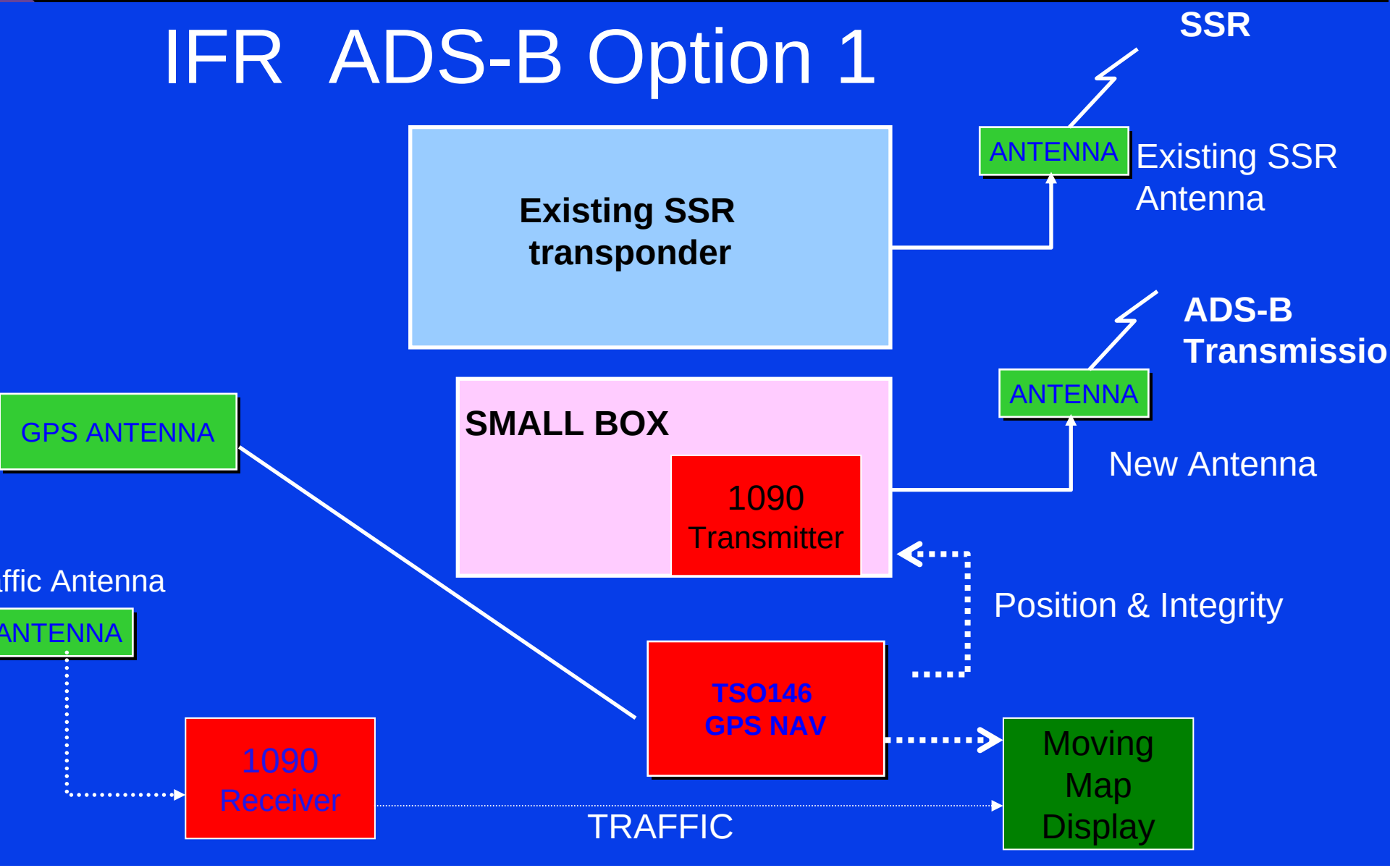
- New Surveillance and New Nav
- If ADS-B exists in aircraft then high quality GPS will exist in aircraft
- If ADS-B is installed – install NAV at same time (& vice versa)

LOWER AIRSPACE Project (LAP)

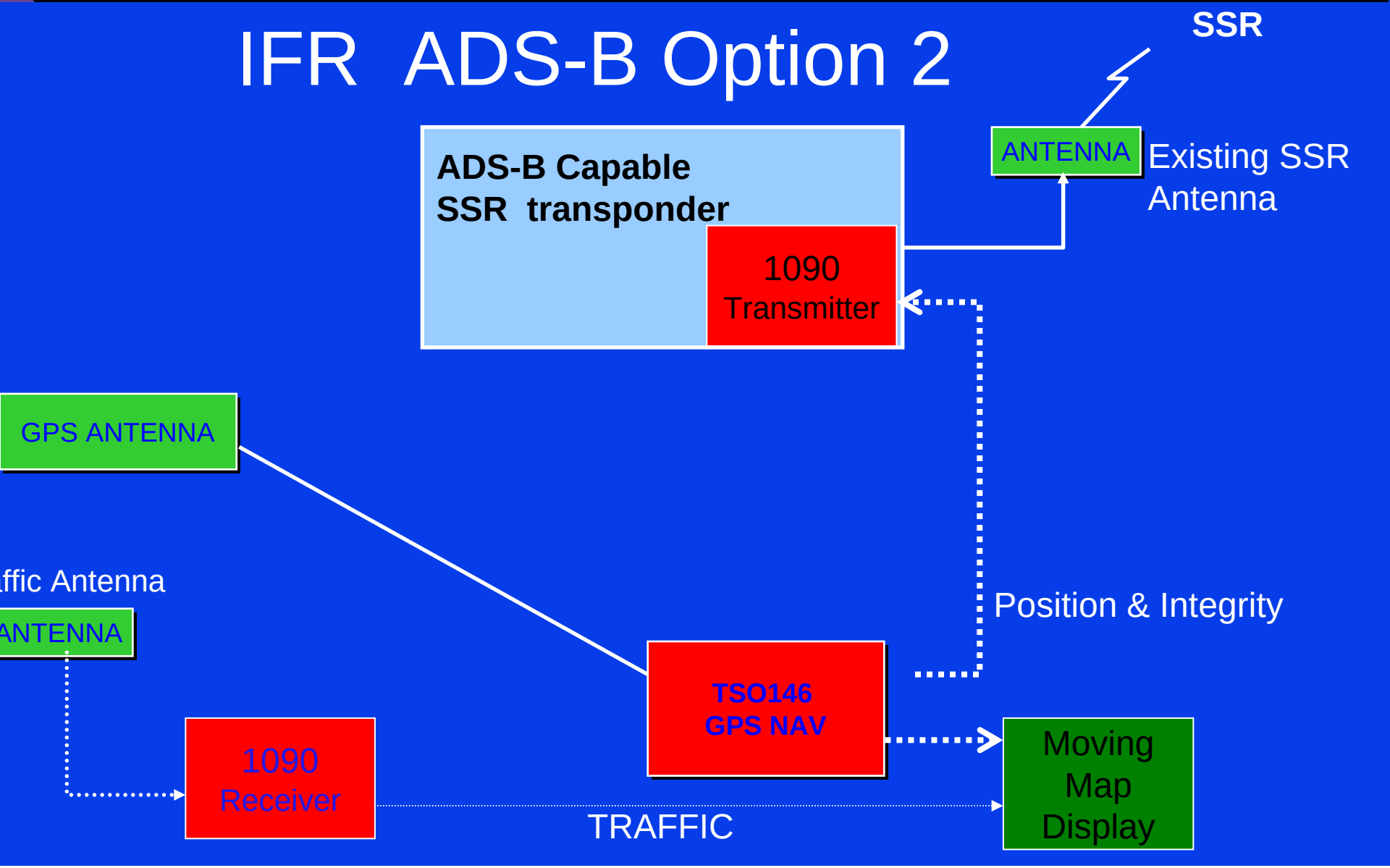
- Industry considering “LAP project”
  - ASTRA, CASA, Airservices Australia
- Remove most NDB/VORs
- Remove enroute radars
- Cross Industry funding to equip GA

  - Access Economics Cross Industry Business case prepared by ASTRA

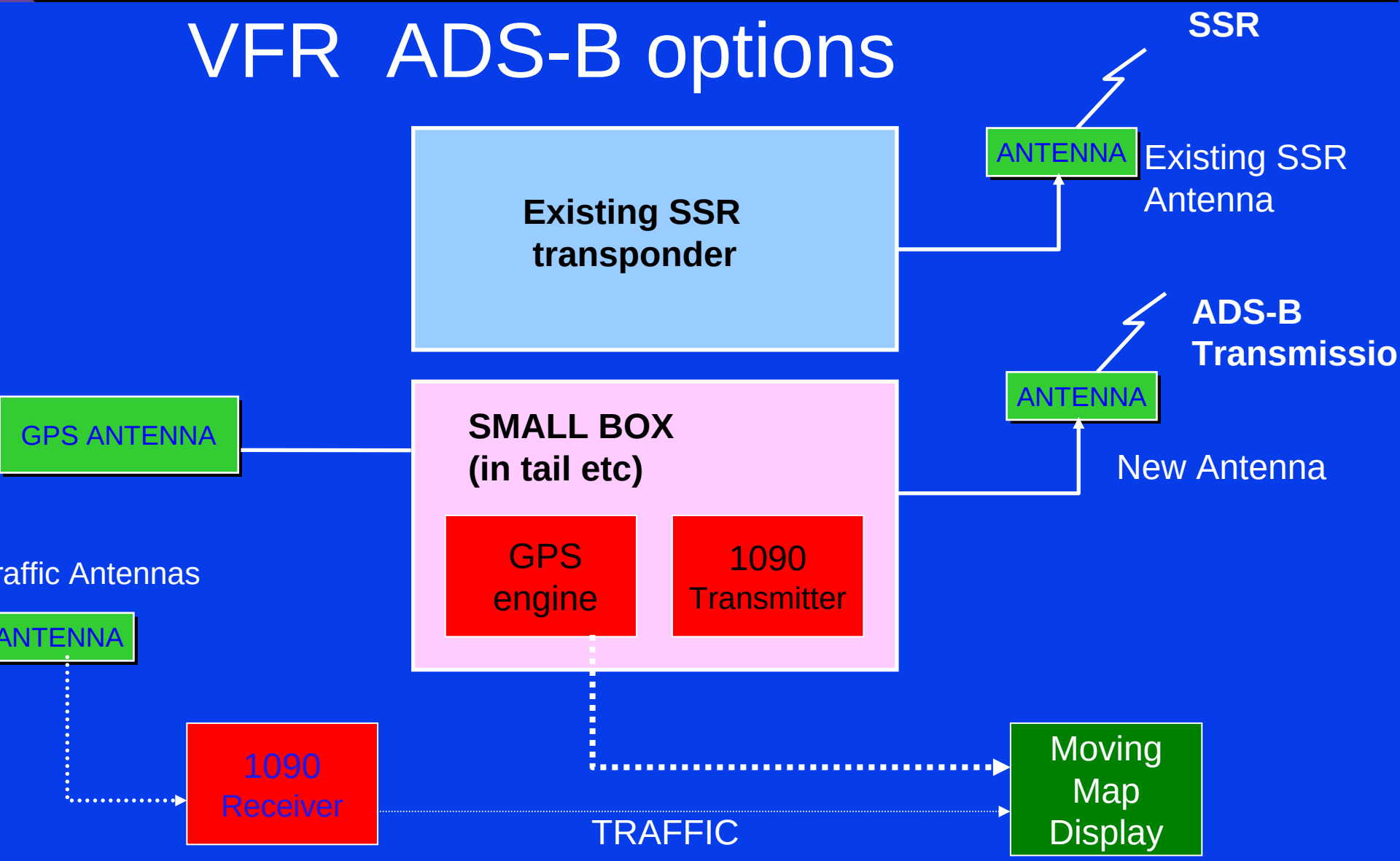
IFR ADS-B Option 1



IFR ADS-B Option 2



VFR ADS-B options



TWO ADS-B TSOs

- C10004
  - SSR Mode A/C transponder with ADS-B out
- C10005
  - ADS-B out only
  - Mandates output of TSO145 positional data too
- Both available at www.casa.gov.au

GA “VFR” CDTI

PDA version

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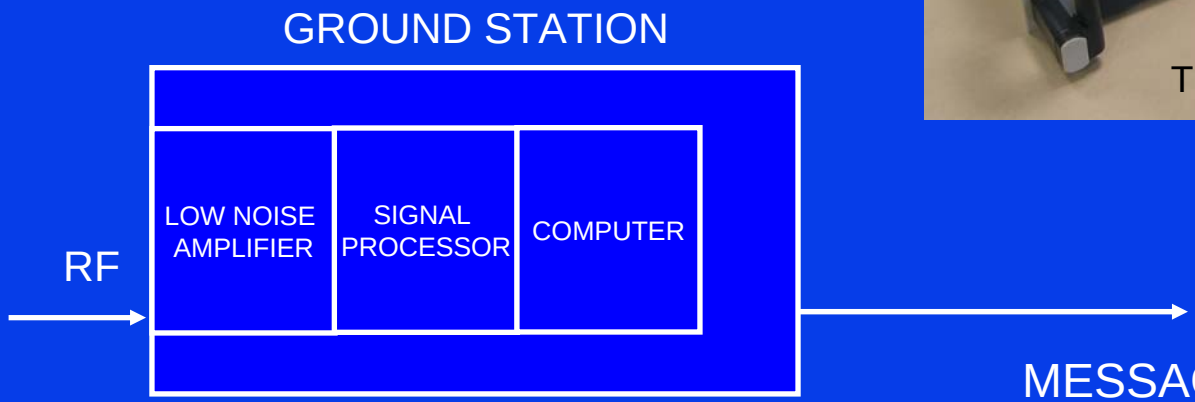
Typical ADS-B Receive only system

DME
OMNI ANTENNA
12 dBi antenna

Thales ATM Ground station



MDS= Better than 90 dB

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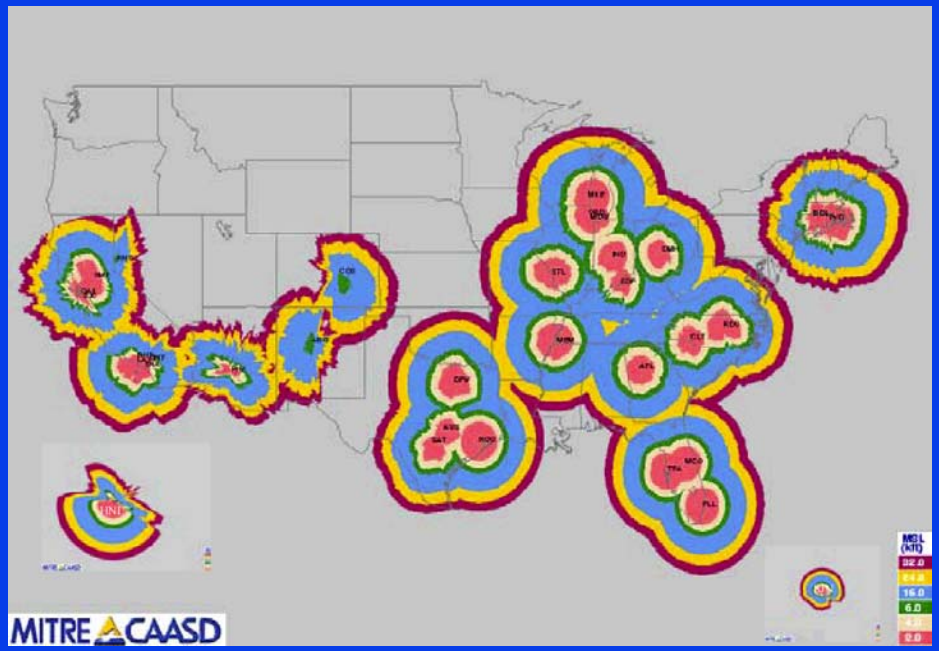
Multi-lateration systems

- Airport surveillance multi-lateration systems use 1090Mhz receivers and decoders
- All commercial vendors offer ADS-B outputs from multi-lateration base stations

SENSIS MULTILAT and ADS-B GROUND STATION



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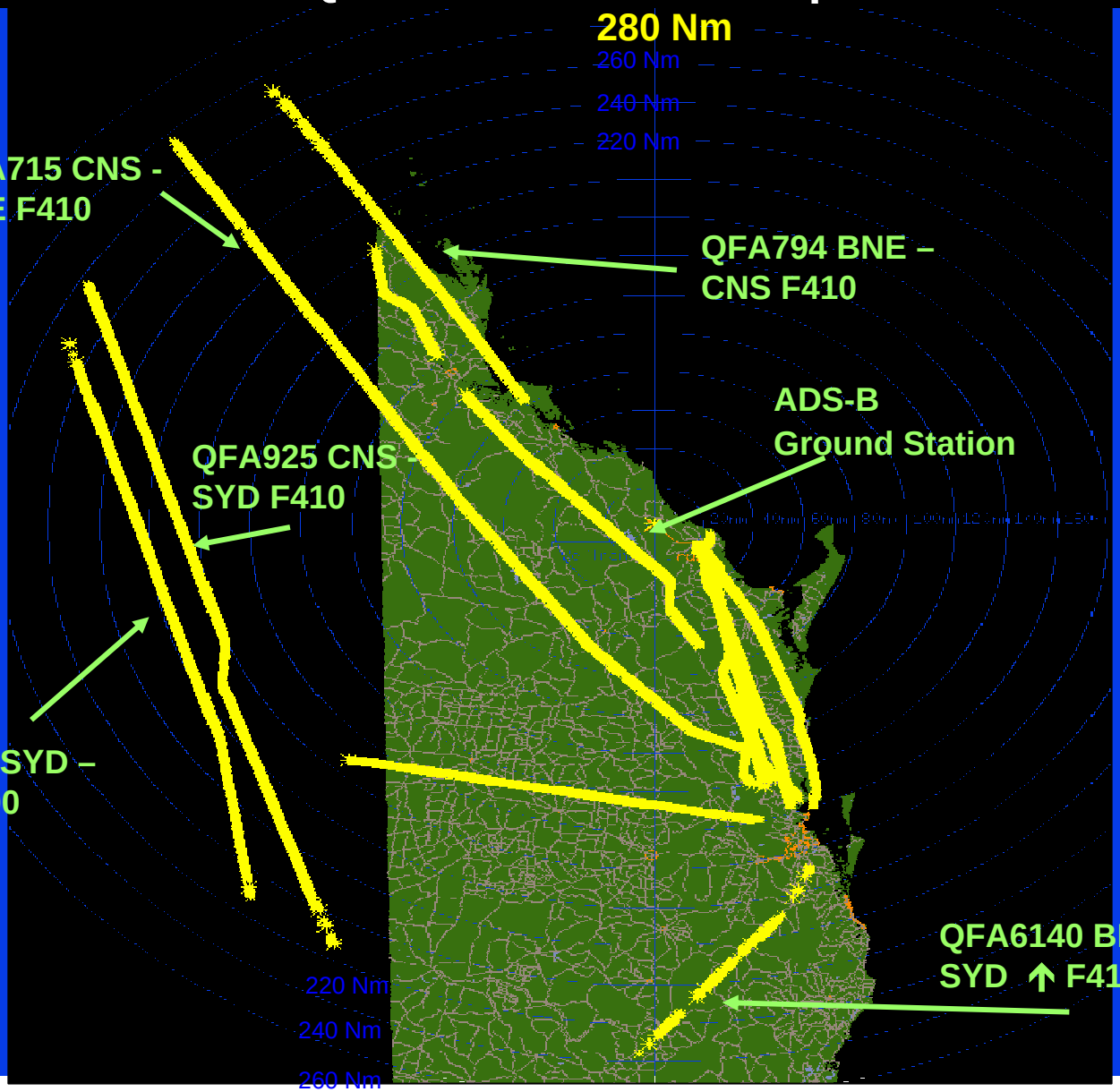
Burnett Basin Trial Experience

ADS-B performance
is BETTER THAN RADAR

Qantas A330 ADS-B Operations

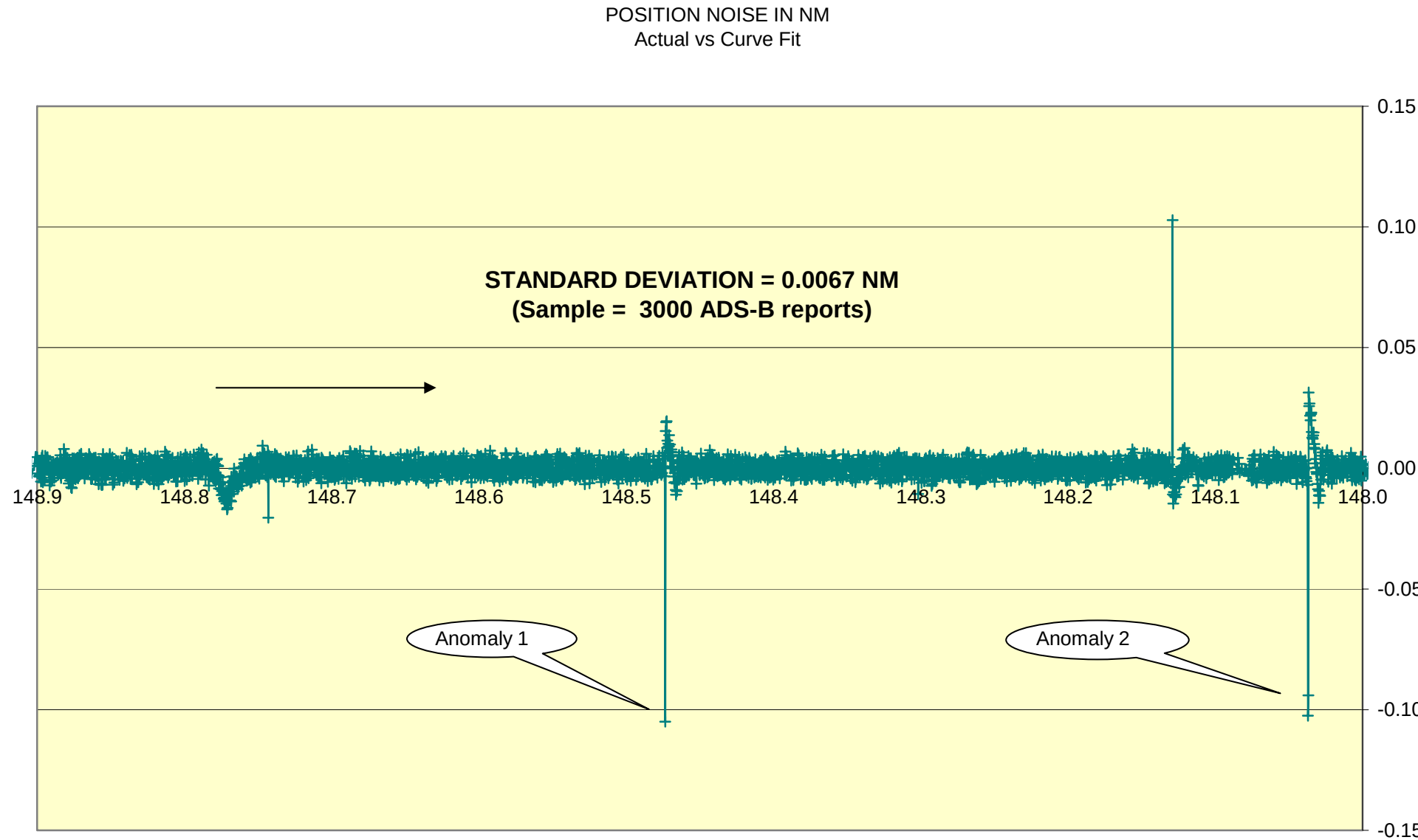
Mode S ADS-B
ves excellent
erformance in
ustralia

nsis Ground station @
ndaberg

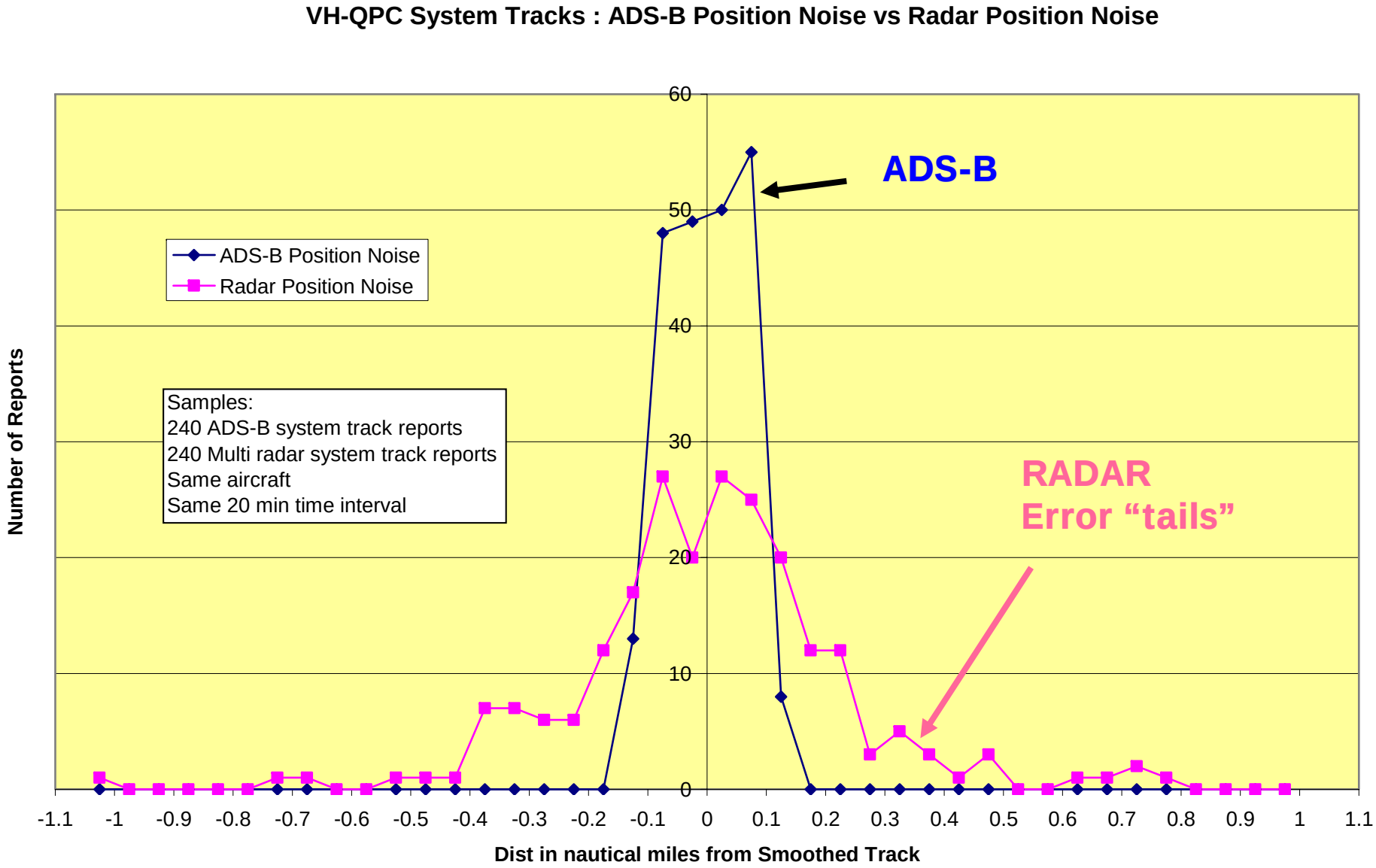


ADS-B on every enroute ATC Console

ADS-B "Noise"

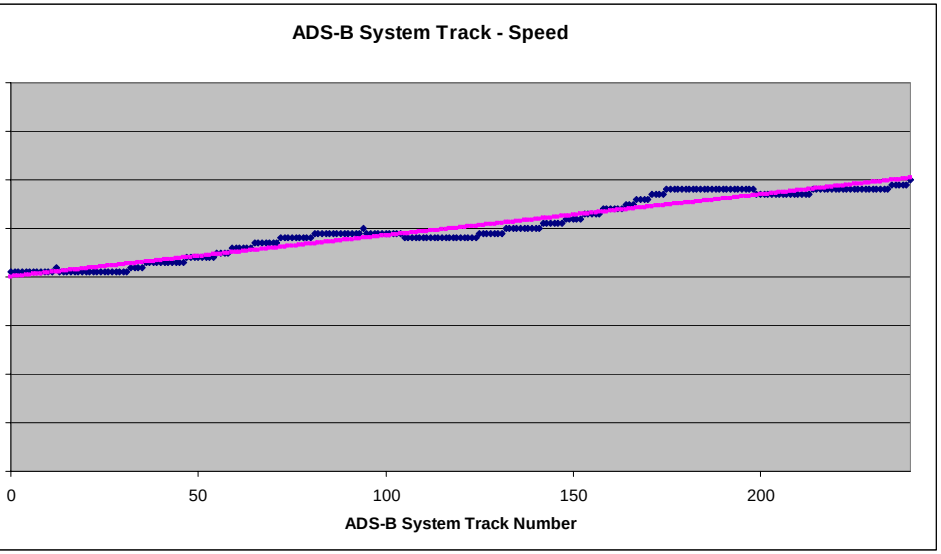


Radar & ADS-B Noise distribution

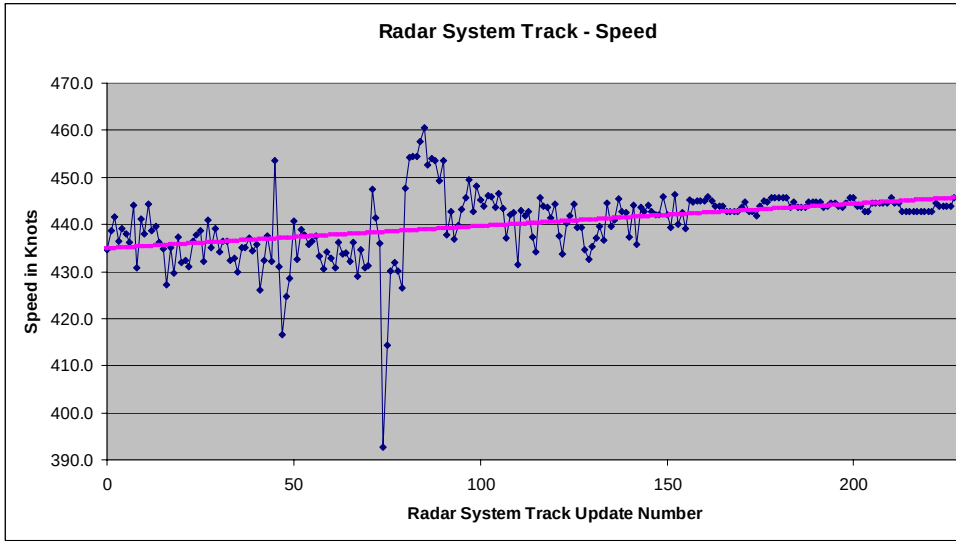


Radar & ADS-B “speed”

ADS_B

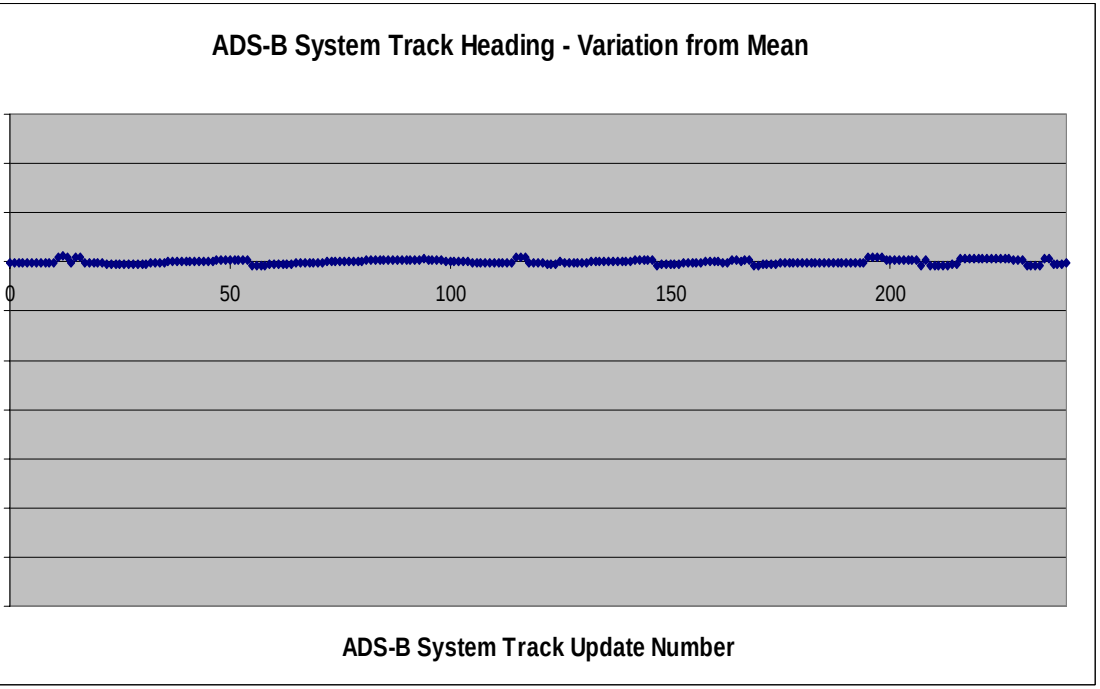


RADAR

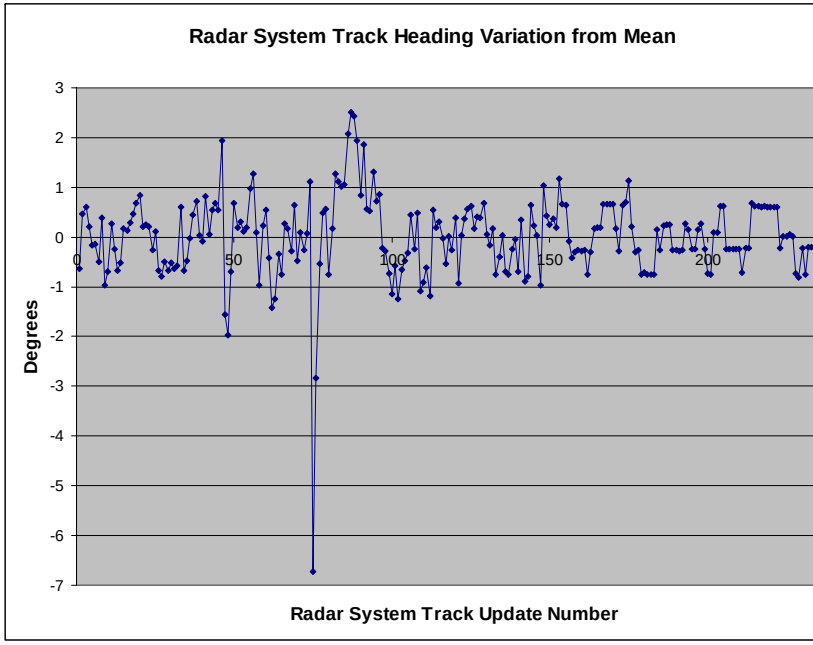


Heading noise

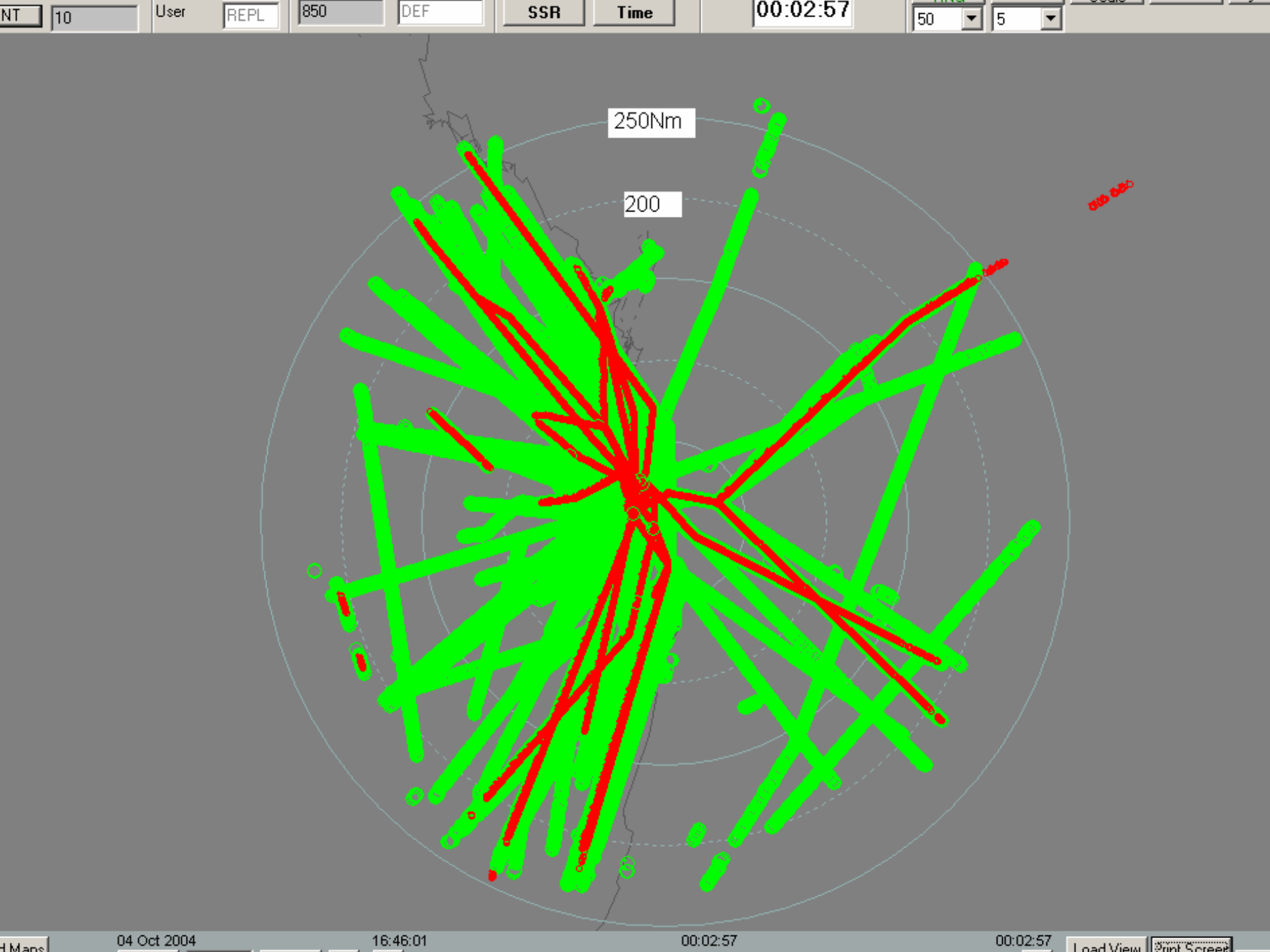
ADS_B

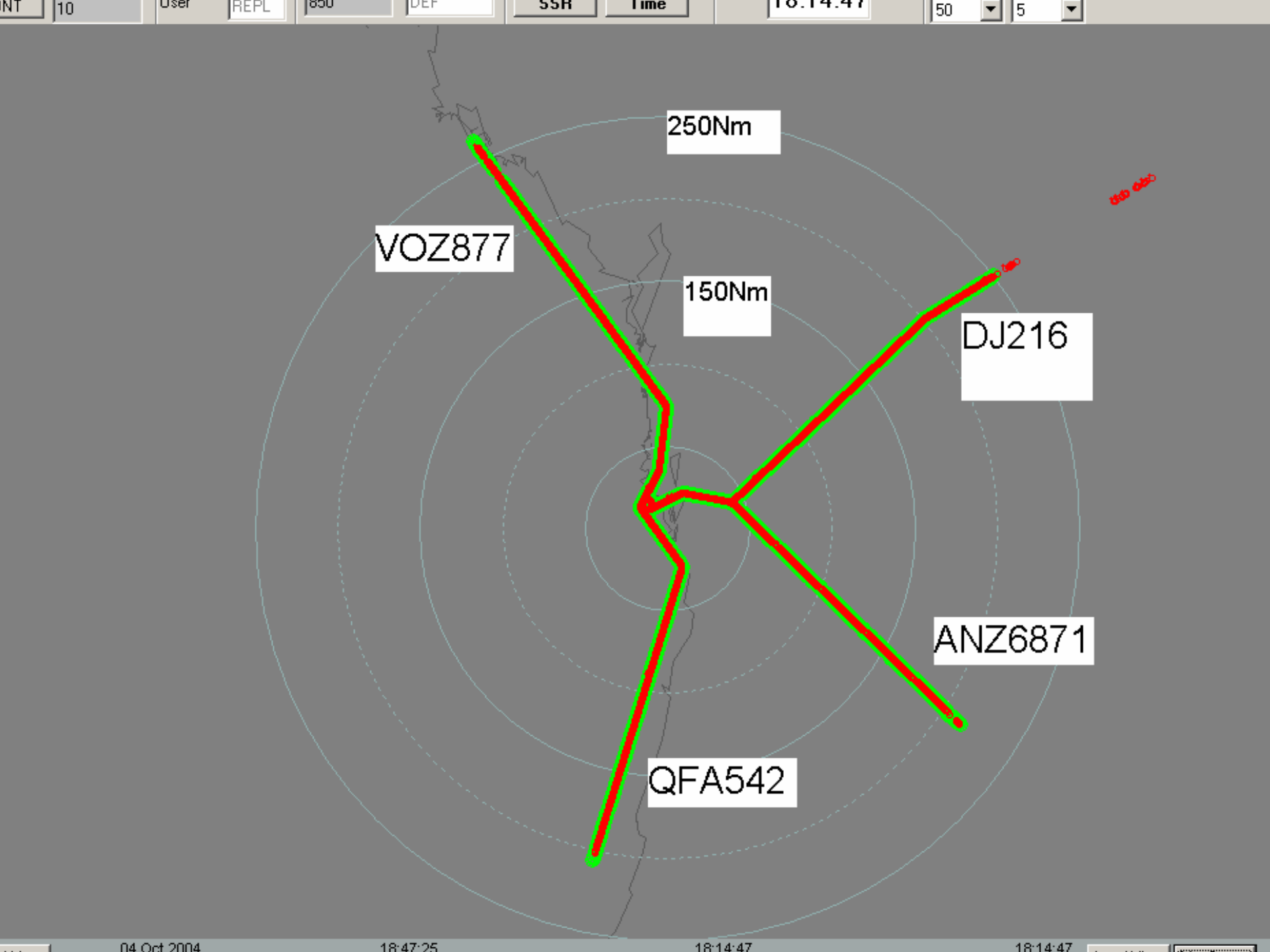


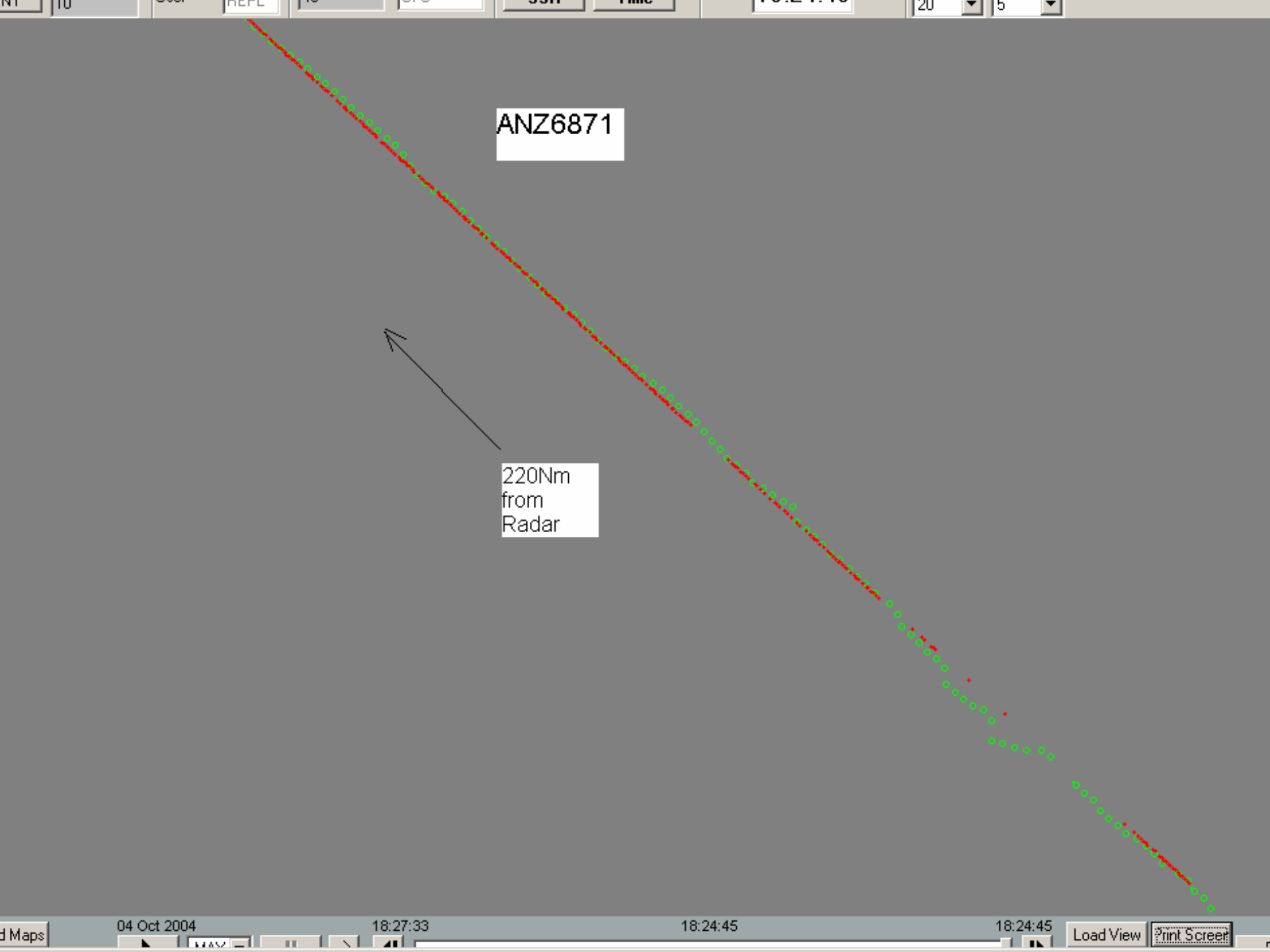
RADAR

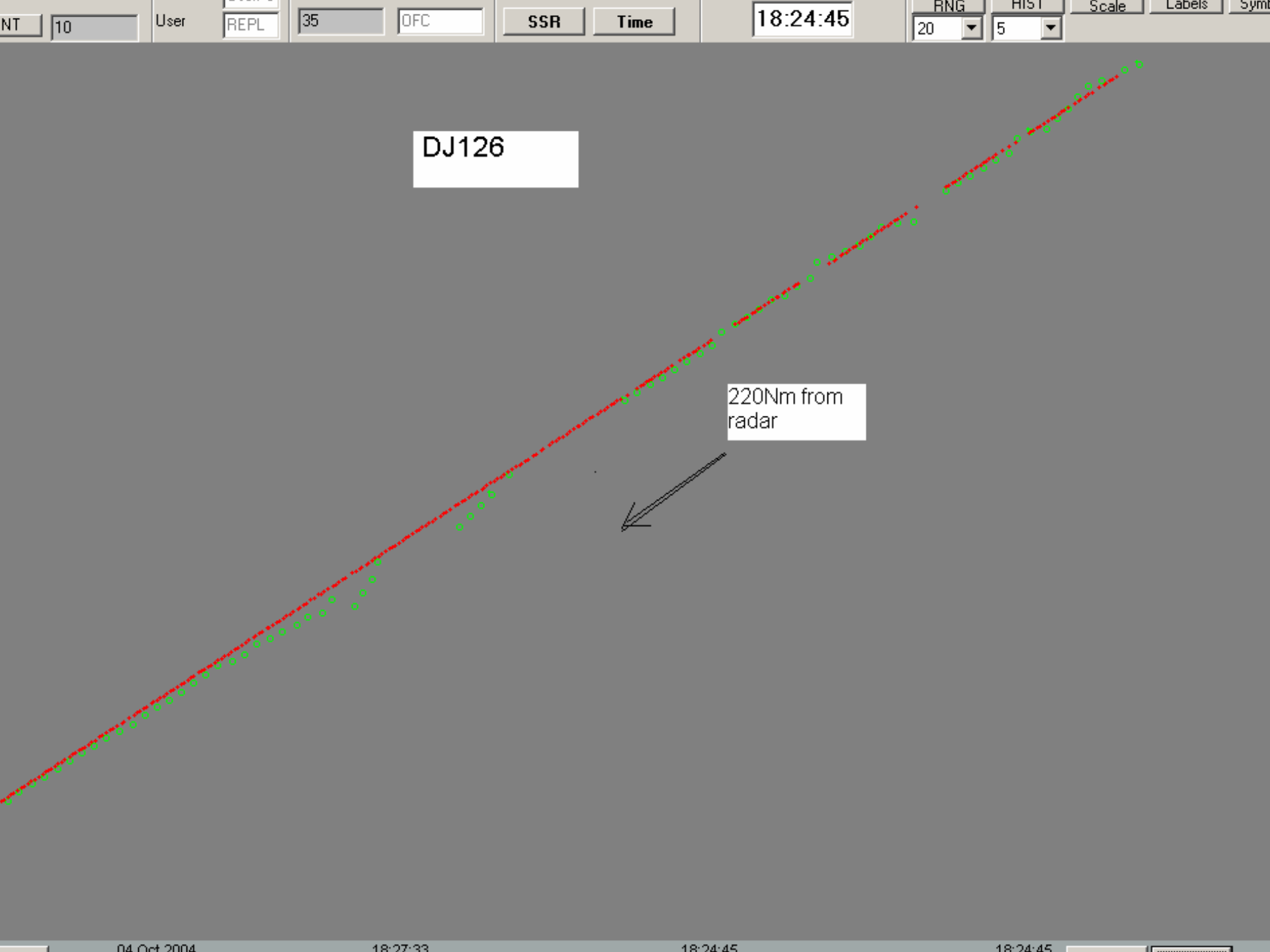


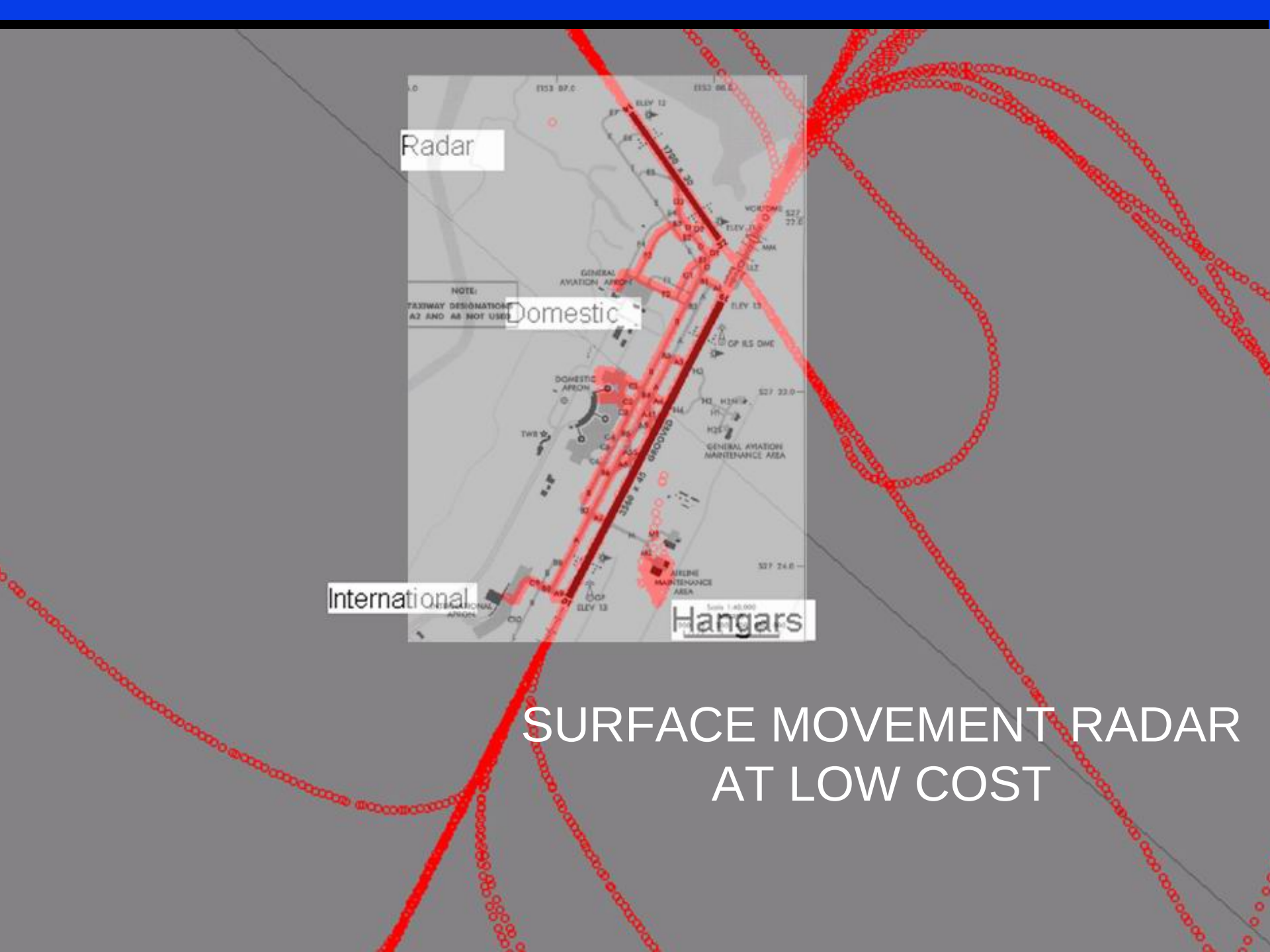
BRISBANE TERMINAL AREA RADAR TOWER


NT
10
User
REPL
850
DEF
SSR
Time
00:02:57
50
5
250Nm
200
04 Oct 2004
16:46:01
00:02:57
00:02:57
Load View
Print Screen


250Nm
VOZ877
150Nm
DJ216
ANZ6871
QFA542


ANZ6871
220Nm
from
Radar
04 Oct 2004
18:27:33
18:24:45
18:24:45
Load View
Print Screen


NT
10
User
REPL
35
OFC
SSR
Time
18:24:45
RNG
20
HIST
5
Scale
Labels
DJ126
220Nm from radar
04 Oct 2004
18:27:33
18:24:45
18:24:45


Radar
Domestic
International
Hangars
SURFACE MOVEMENT RADAR
AT LOW COST

What is needed for ATC useful ADS-B ?

- ADS-B out fitted to aircraft
  - GPS output including INTEGRITY ‘
  - Transponder software (or hardware if old transponder)
- ADS-B Ground station
- ATC system to display ADS-B
  - Preferably integrated (Tower systems could be standalone)
  - Links to get data to ATC system
- ATC procedures & Training

Thank you

Questions?