CGSIC

GPS for ICAO Global Tracking

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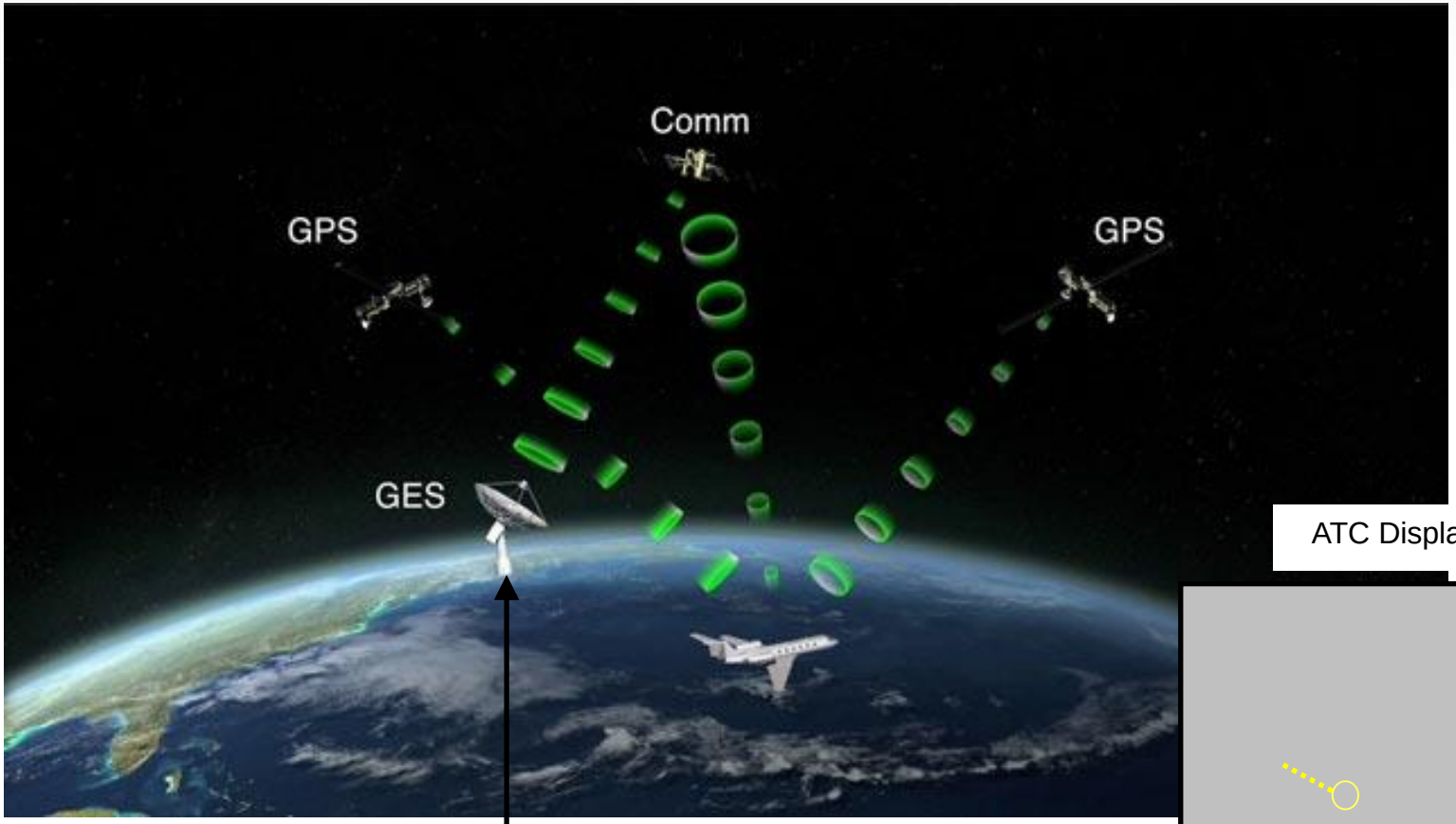
Need

- Loss of AF447 and MH370 highlighted need for tracking of aircraft
- Socially not acceptable to not know aircraft location at all times
- ICAO Global Tracking Conference (May 2014):
  - Position report every 10 minutes (ops normal)
  - Position report every 1 minutes (ops non-normal)
- ICAO High Level Safety Conference (Feb 2015):
  - Position report every 15 mins (ops normal)
  - Locate wreckage within 6 NM
  - Take advantage of existing surveillance systems
- ICAO Performance Standard for Global Tracking being developed

Operational Context (Australia)

- Controlled Airspace - ATC Services
  - Continental airspace
    - Surveillance (tracking) by ATC radar / ADS-B (since 2005)
  - Oceanic airspace
    - implies Automatic Position Reporting, messages by Satcom
- 90+% of wide-body aircraft equipped with FANS-1/A ADS-C
- Airservices ATC Automation System supports FANS-1/A ADS-C
- ADS-C already in routine service in Australian FIRs (20 yrs)
- Non normal aircraft operation can be detected by monitoring of lateral & vertical conformance to ATC Clearance
  - Clearance is known to ATC & Pilot but not to the Airline base
- Use of one system to provide ATC Surveillance and aircraft Global Tracking allows cost to be offset by improved ATC service (smaller separation standard increases probability of optimum route & altitude)

FANS-1/A ADS-C



ATC Display System

XYZ 456
FL 300

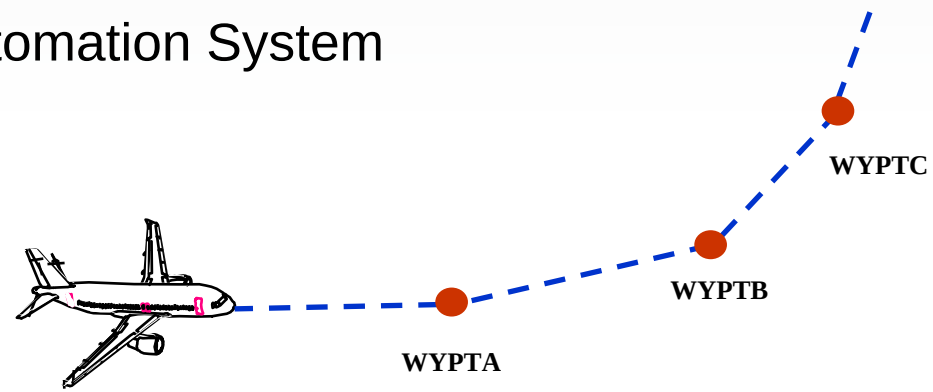
ABC
123
FL 280

ADS-C
Message
Processor

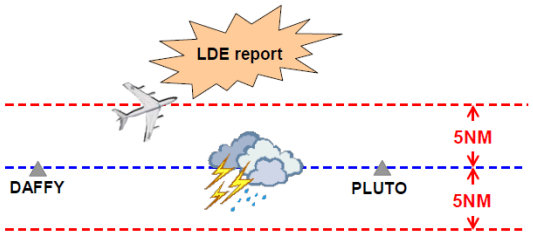
ADS-C Contracts

Contracts – Aircraft FMC to ATC Automation System

- Periodic Position Report
  - Aircraft position
- Waypoint Change Event
  - Occurs when Next or (Next + 1) waypoint changes
  - ADS-C Route Conformance Warning (ARCW)



- Event – Lateral Deviation Event - route conformance
- Event – Level Range Deviation Event - flight level conformance
- Demand - also known as one shot
  - can be initiated by controller at any time



Concept

- Adapt existing FANS-1/A ADS-C surveillance
  - Less than comprehensive solution but available today

- Automatic Position Reporting
  - **GPS** provides aircraft position and time tag
  - Reporting rate (aircraft operations normal) = 1 per 14 min
    - ATC System check Position & Altitude against Clearance

  - ATC System checks for missed messages
  - Controller can set higher reporting rate as required

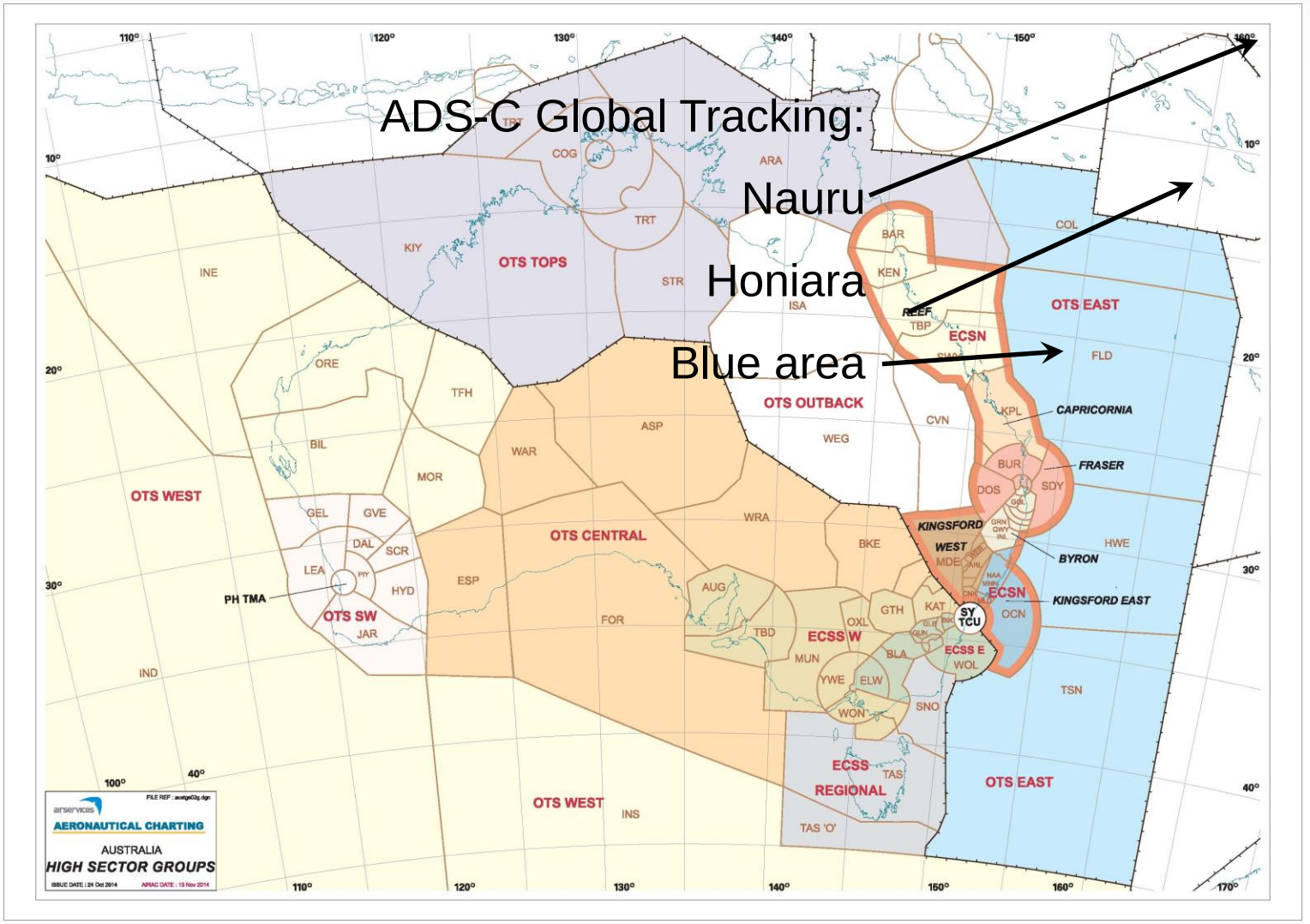
Concept …

- Automatic, timely detect of (serious) non normal operations
  - Aircraft off path - Lateral or Vertical deviation
    - if on route & altitude will reach intended destination
  - Check route consistency – aircraft FMC to ATC automation (ARCW)
    - FMC Reports Level (altitude) Range Deviation (LRDE)
    - FMC Reports Lateral Deviation Event (LDE)
- Non-normal events reported / displayed to the Controller
  - Missed message; failure to pass waypoint on time (ETO)
  - Inconsistent route (ARCW), Route Adherence Monitor (RAM)
  - Cleared Level Adherence Monitor (CLAM), Pilot declared Emergency
- Automatic New Contract - reporting rate ops non-normal (1 per 5 min)
- ATC Procedures define response to non normal operation
  - Lost Comms Procedure → SAR Procedure

Proof of Concept

- Partners
  - Airlines
    - Virgin Australia: B777 x5 & A330 x5
    - Qantas: A380 x12, B744 x12 & A330 x26
  - ANSP/ATC
    - Airservices
  - Communications Providers
    - Inmarsat (sitcom) , SITA & ARINC (datacom)
- Location
  - Oceanic east of Australia (OTS East) plus Nauru & Honiara FIRs
  - 10 min reporting (ICAO recommendation May 2014)
- Operations commenced on 30 Jan 2015

Proof of Concept …



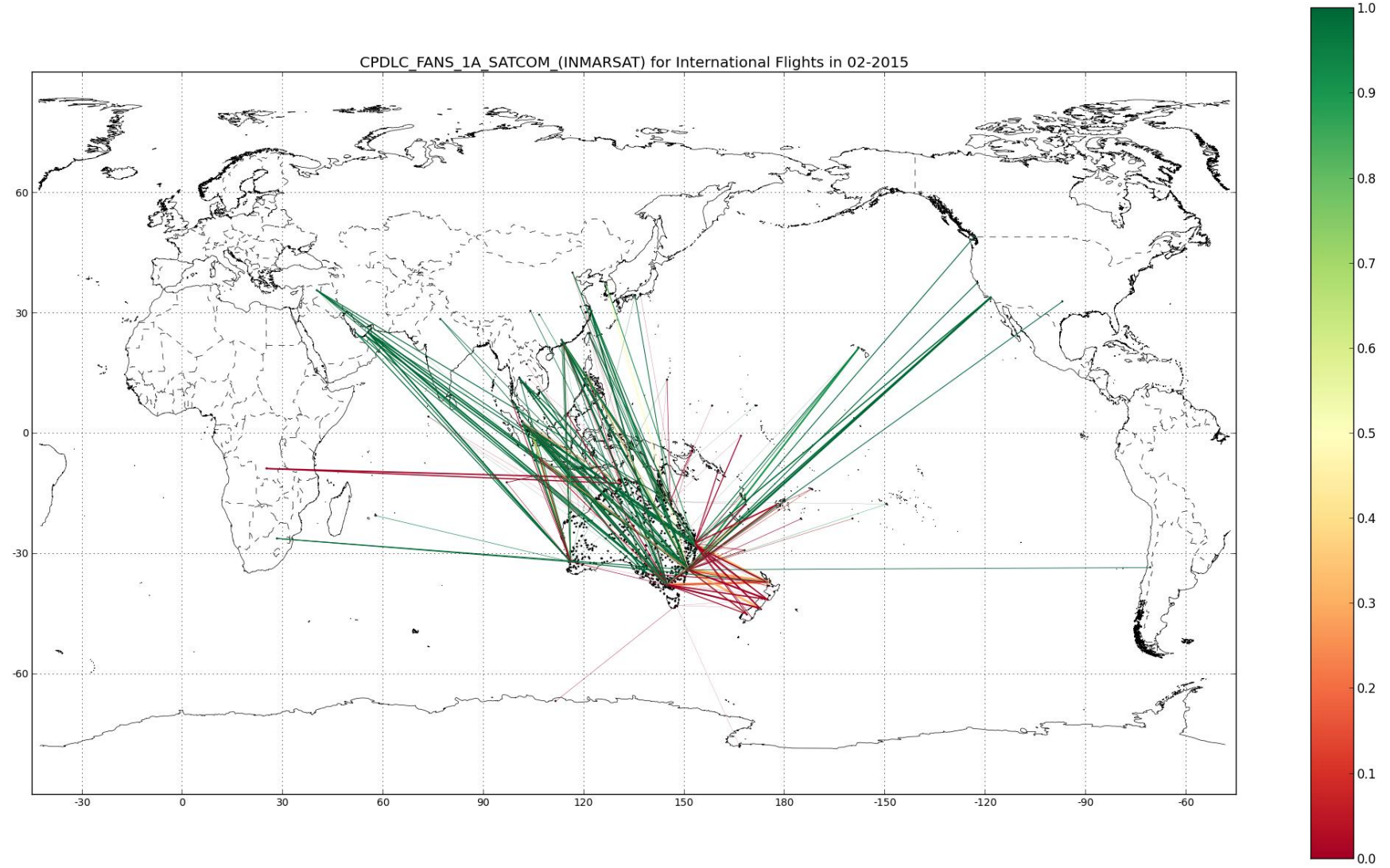
Phased Implementation

- Prime Consideration:
  - Care to ensure not overload:
    - Satcom – **Biggest Concern** – limited bandwidth, cost
    - Data Comm networks (SITA & ARINC)
    - ATC Automation System FANS-1/A processing
- Satellite Communications Modelling:
  - Increase in Periodic Reports; Decrease in Rate Change messages
  - 4% increase in downlink; 17% decrease in uplink
  - Messages recorded; message rate and latency analysed
    - Negligible increase in total message count
      - Increase in periodic message count as expected
      - Decrease in rate change message count as expected
    - No loss of performance, no increase in latency
    - No signs of distress

Phased Implementation …

- Phase 2
  - 14 min ops normal reporting
    - Meets ICAO HLSC (Jan 2015) 15 min requirement AND
    - ATC 30/30 NM Procedural Aircraft Separation Standard
  - Extend service all ADS-C A/C in Brisbane/Honiara/Nauru FIRs
  - Commenced 1 May 2015
- Phase 3
  - Extended service to include all ADS-C Aircraft in Melbourne FIR
  - Commenced 29 May 2015
- New Zealand – commenced 29 May 2015
- USA (Anchorage & Oakland FIRs) commenced 25 June 2015
- Malaysia has increased their tracking rate
- Discussions with Indonesia, Fiji & South Africa

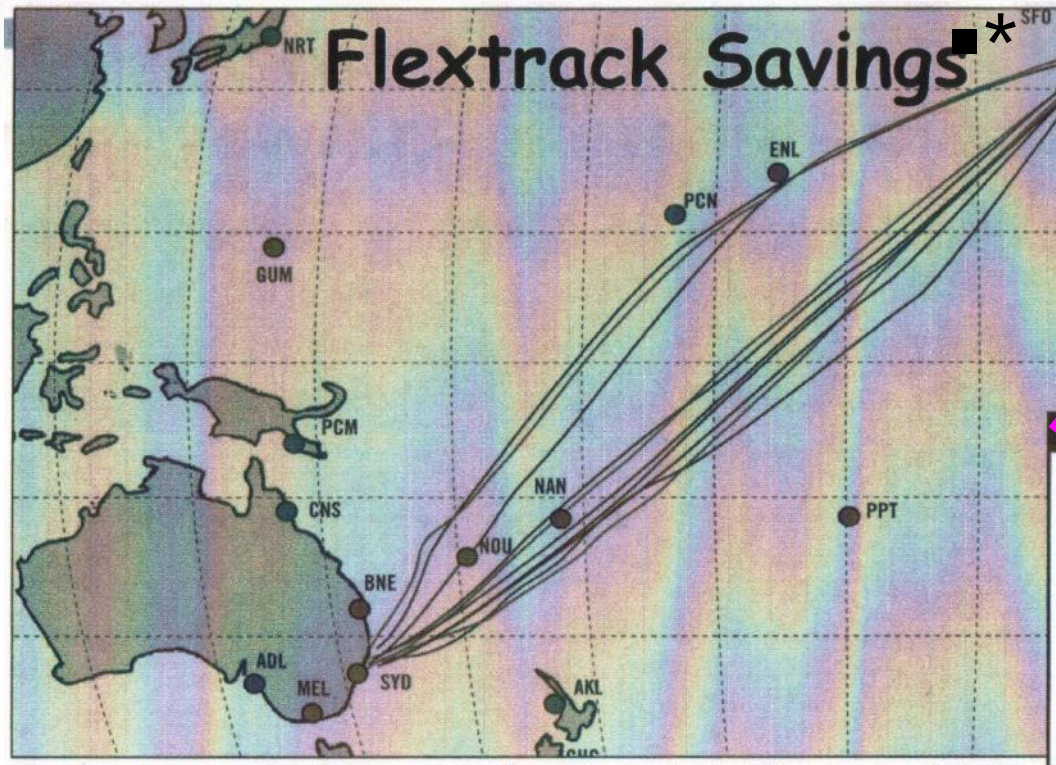
Benefit Achieved



Benefit Achieved …

- Wide Body Aircraft - ADS-C equipped
  - A330 / A340 / A380 / B744 / B777 / B787
  - 7,370 operations / month = 65%
- Narrow Body Aircraft - not ADS-C equipped
  - A320 / B737
  - 3,990 operations / month = 35%
- Passenger exposure (passenger hours)
  - Passengers carried (average)
    - Wide Body 300 to 550 – average 400 passengers
    - Narrow Body – average 180 passengers
  - Flight duration (av) – Narrow Body: 4 hours; Wide Body: 11 hours
  - Wide Body = 91.9% Narrow Body 8.1%
  - Benefit achieved for 91.9% of passenger hours

User Preferred Route



Month	Saving (min)
JAN	4.9
FEB	2.4
MAR	23.1
APR	29.0
MAY	23.8
JUN	28.3
JUL	6.5
AUG	13.3
SEP	10.5
OCT	5.3
NOV	2.5
DEC	6.3

Figure 2. Los Angeles-Sydney daily flexible track plot for one week (with optimum daily routes in black and optimum fixed-track routes in red). Box indicates time saving achieved for different months of the year.

- 2.4 < 29 mins * 8 flights = 0.3 < 3.8 flt hours/day
- 0.3 < 3.8 hr @ 11 tonne/hr = 3.3 < 41.8 tonne/day
- 3.3 < 41.8t * 10.8 * 59 * 1.48 = $ 3,112 < 39,420 AUD/day
- 3.3 < 41.8t * 3.3 = 10.9 < 138 tonne CO_2/day

30/30 NM – small separation standard greater probability of optimal altitude

Next Steps …

- Explore solutions for non ADS-C equipped aircraft
  - Significant numbers of A320 & B738 oceanic flights to/from Aust
  - Across the Tasman to New Zealand
  - Northern Australia to holiday destinations in Asia

- Need a sitcom link of some sort
  - driven by customers wanting internet / wifi

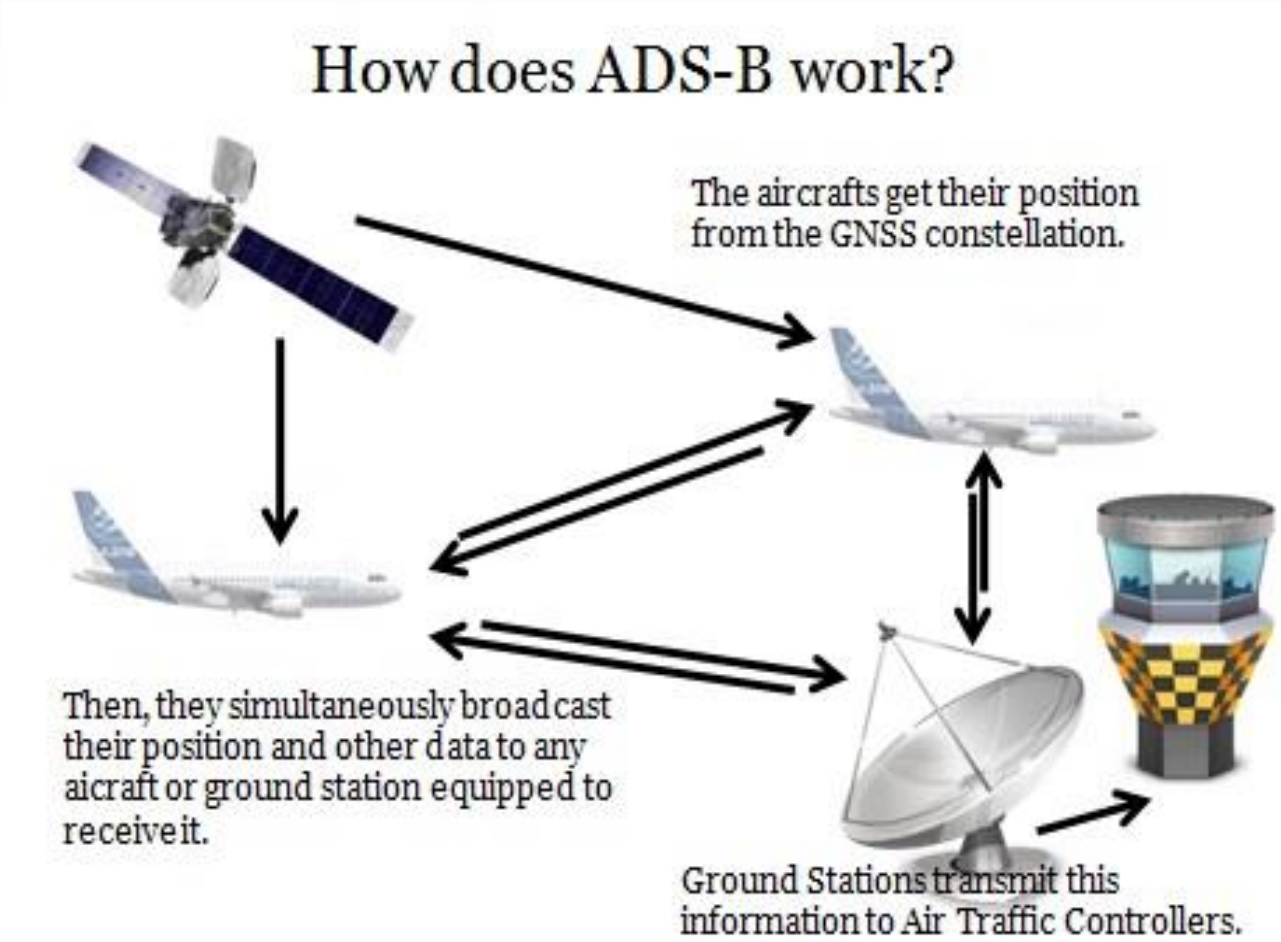
Complimentary Developments

- SITA & ARINC Developing Display Systems for Airlines
  - Uses ADS-C messages
    - ATC initiated messages (when available)
    - else Initiate ADS-C messages themselves
  - Fuse ADS-C data with (any) other aircraft positional data
    - ADS-B
    - Radar

Summary

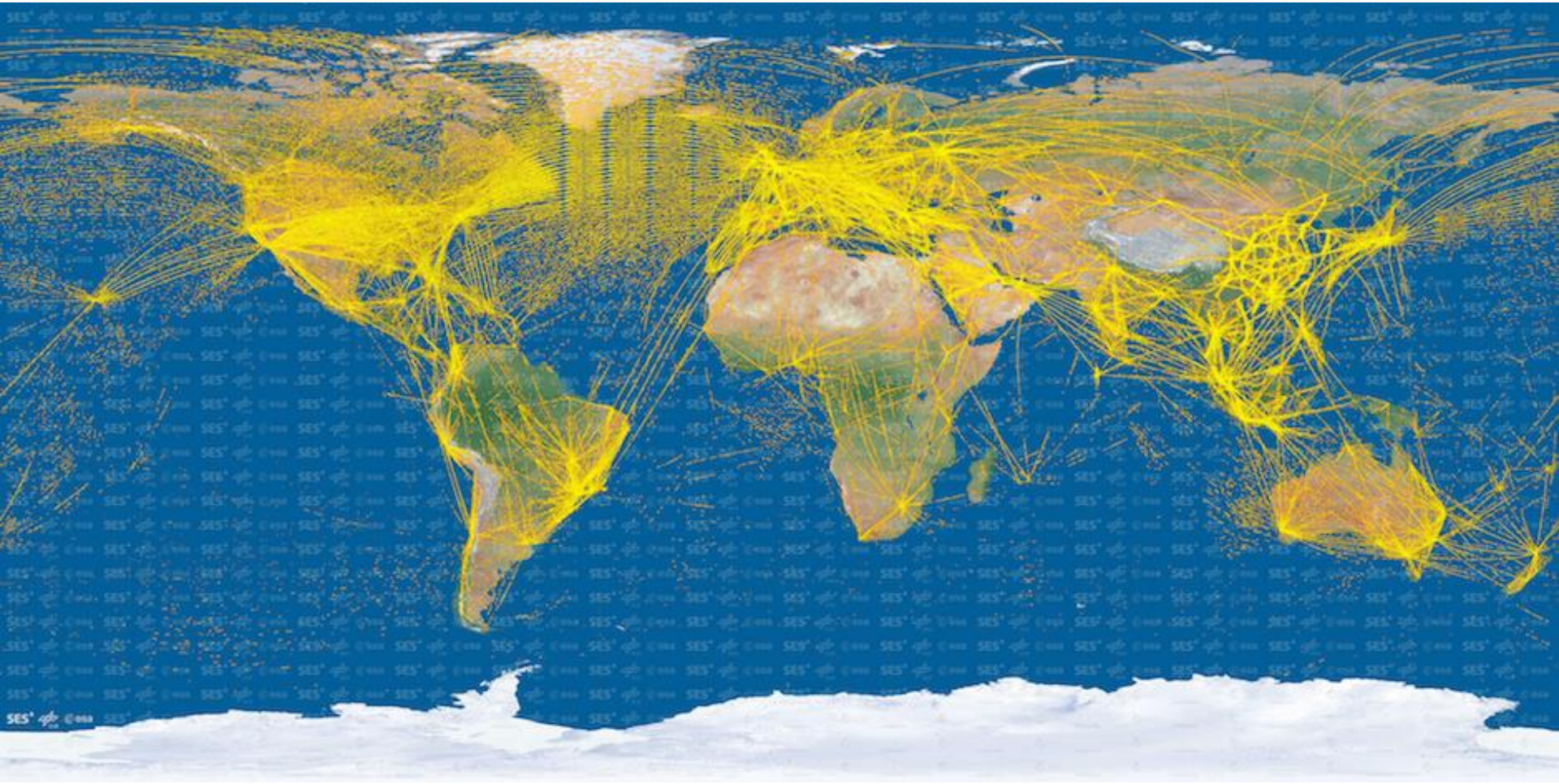
- GPS / ADS-C meets the intent of HLSC recommendation on Global Tracking **today**
- GPS / ADS-C fitted to most wide body aircraft operating oceanic
- GPS / ADS-C Global Tracking to 92% of passengers flying oceanic
  - in/out of Australia (will be different for other countries / routes)
- Display to ATC and / or Airline
- Cost is a modest (~4%) increase in ADS-C messaging
- Cost can be more than offset by more efficient aircraft operations
  - greater use of lateral separation (50/50 or 30/30 NM)
  - greater probability of optimum altitude (operating efficiency)

GPS & ADS-B



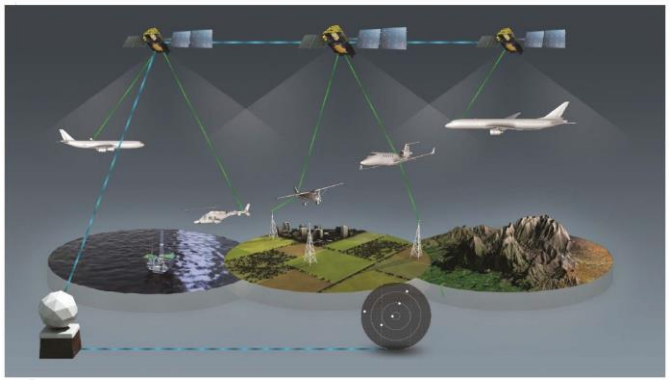
- Aircraft Position
  - GPS
- Broadcast
  - Ground
  - Aircraft
  - (direct) Satellite reception

GPS & Space ADS-B



Satellite ADS-B data gathered by ProbaV confirms feasibility !

GPS & Space ADS-B …



- multiple Proposals
- multiple Architectures
- multiple Comms Constellations

- Aircraft Position – **GPS**
- LEO satellite(s) receives aircraft's ADS-B signal
  - Pass ADS-B message satellite to satellite to ground station
  - Pass ADS-B message LEO satellite to GEO satellite to ground station

- LEO satellite constellation
  - 60 to 100 satellites
  - Satellites
    - Large, long life, expensive
    - small, short life, cheap

- Aircraft position information sold as a service – how much? when?

Thanks

- GPS has continually improved:
  - Robustness - 27 Satellite geometry
  - Accuracy – SA off and Equivalent User Range error decreased
  - Availability – aviation practical purposes 100%
  - Reliable

- Women and Men who pioneered / developed / operate GPS:
  - You have our Sincere thanks for the truly exceptional Service

- Politicians & Administrators:
  - GPS gives immense Safety, Environment and Economic benefit
  - Ubiquitous in all aspects of life; value under recognised
  - Easy to take for granted
  - GPS needs to be protected, fostered, replenished, grown

Any Thoughts