Global ATC Surveillance via Satellite ADS-B

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Presented by John Taylor

Outline

- ADS-B refresher and summary of satellite reception
- Expansion of ADS-B surveillance coverage in remote areas of Canada to date
- Air traffic control in oceanic remote regions today
  - an examination of the North Atlantic Tracks (NAT) as an example
- Global extension of ADS-B via satellite
- Brief description of ADS-B sensors onboard satellite
- Benefits assessment
- Receiver detection probability modelling
- Ongoing studies and RF environment

ADS-B refresher and summary

- ADS-B is an air to air, air to ground autonomous surveillance application
- Has been in use since the mid to late 1990's
  - aircraft transmits on 1090 MHz autonomously using PPM that has error correction
- Reception of existing ADS-B transmissions at the satellite is planned
- Satellite reception has no change or impact on existing RF environment (being proven in stochastic analysis)
- No changes required to aircraft avionics or certification
- Mainly intended for oceanic, Polar and remote regions

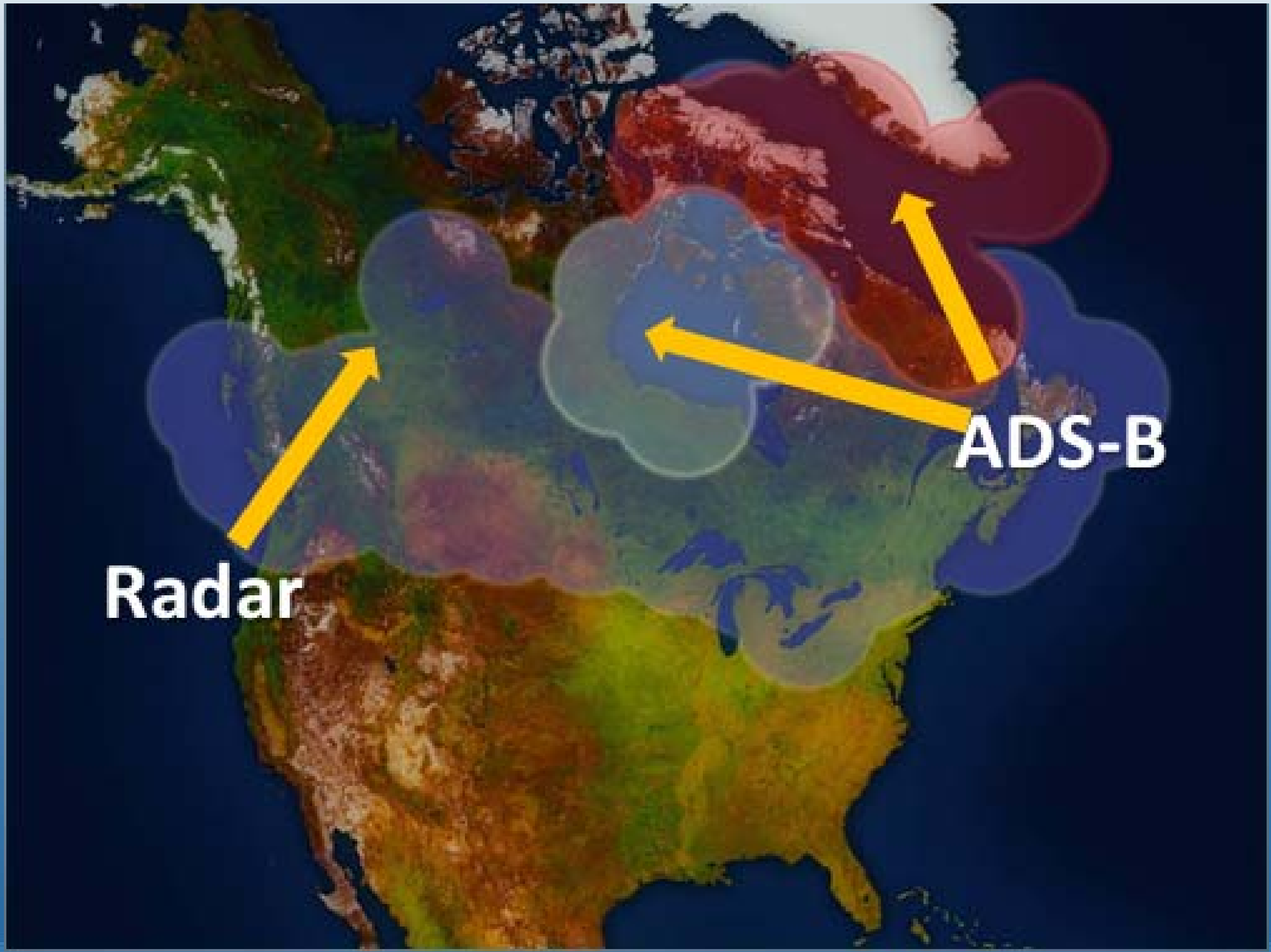
ADS-B deployment in Canada

- In 2009 first network of ADS-B commissioned in the airspace over Hudson Bay in Northern Canada.
- Five ground stations provided surveillance for the first time to 850,000 square kms of airspace used by approximately 35,000 flights a year.
- Extensive annual fuel savings from this expansion alone.

ADS-B deployment in Canada

- November 2010, ADS-B installations along the northeastern Coast of Labrador and Baffin Island added another 1,920,000 sq kms of surveillance
- March 2012 ground stations in Greenland added another 1,320,000 sq kms of ADS-B surveillance over a portion of the North Atlantic.

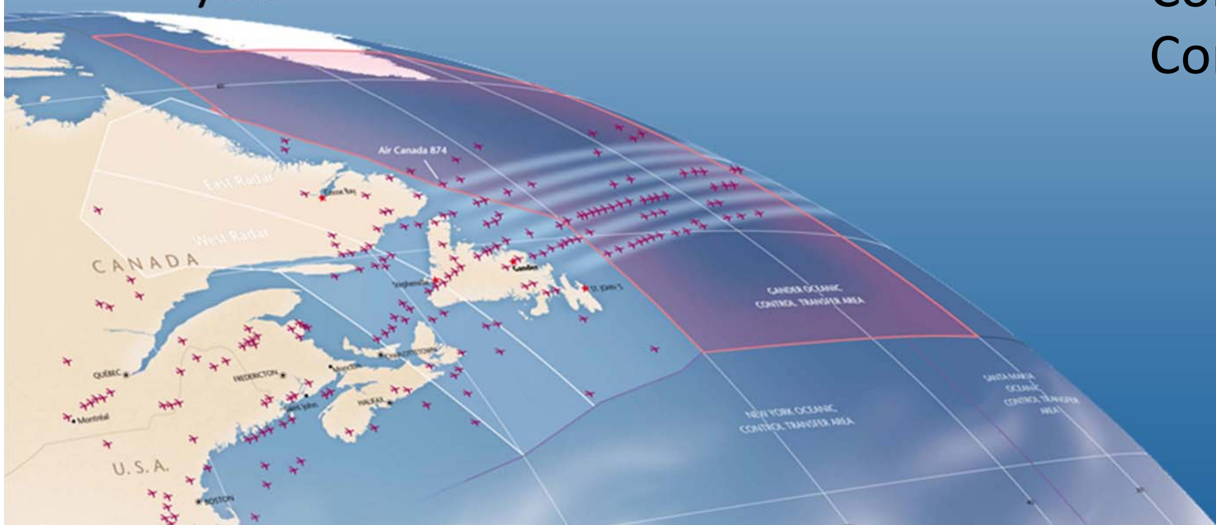
Surveillance – Radar + ADS-B



The NAT today

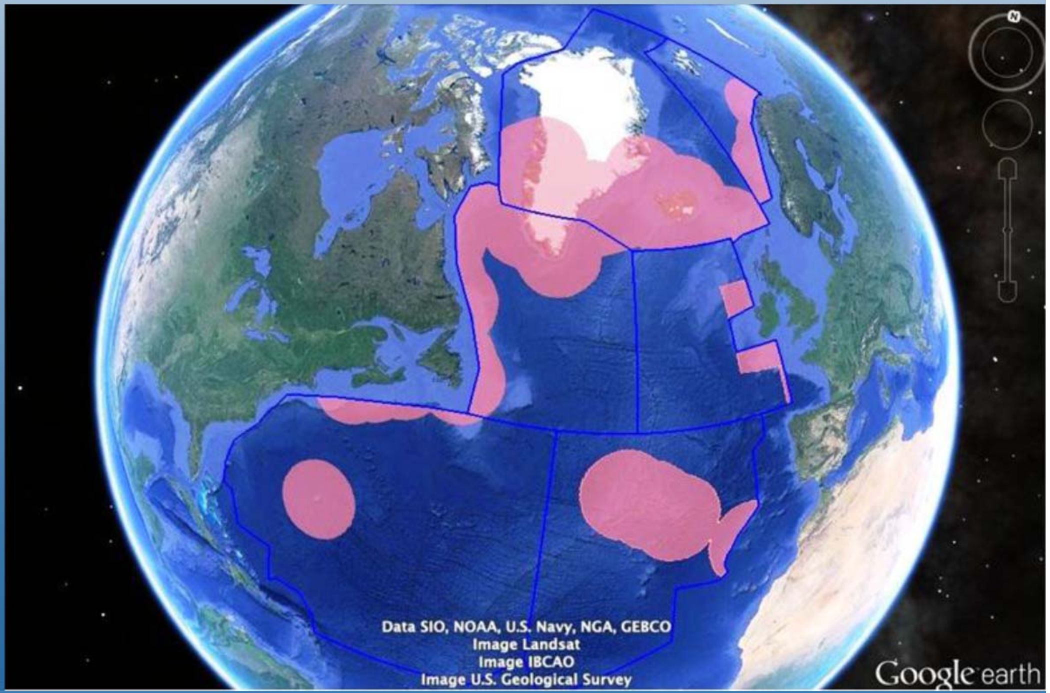
- **1,000** flights per day (1,300 peak summer day)
- **350,000** commercial flights per year
- **+23,000** military & GA flights per year

- **90%** of the flights are already ADS-B equipped
- **78%** of flights are Data Link (FANS 1/A) equipped
- **80%** are capable and use Controller Pilot Data Link Communications (CPDLC)



Surveillance limitations on the NAT

- Even with specific initiatives by NAT ANSPs to lever ground based surveillance to the maximum potential, surveillance of this strategic and economically important area of airspace remains limited.

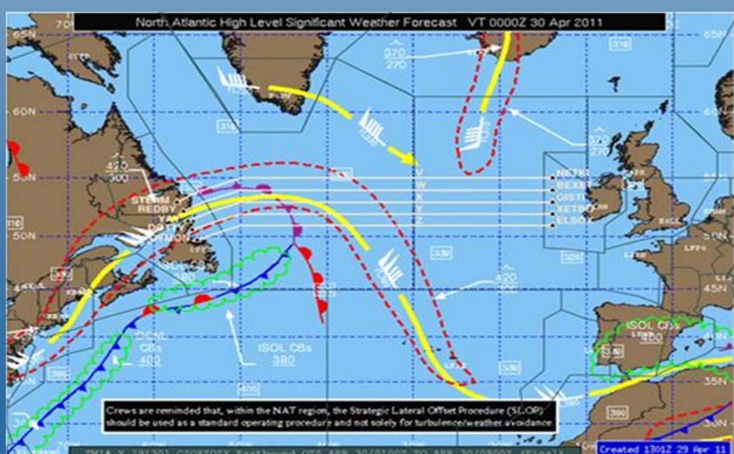


- Air traffic control must use procedural separation rules that often limit flexibility in order to maintain safety.

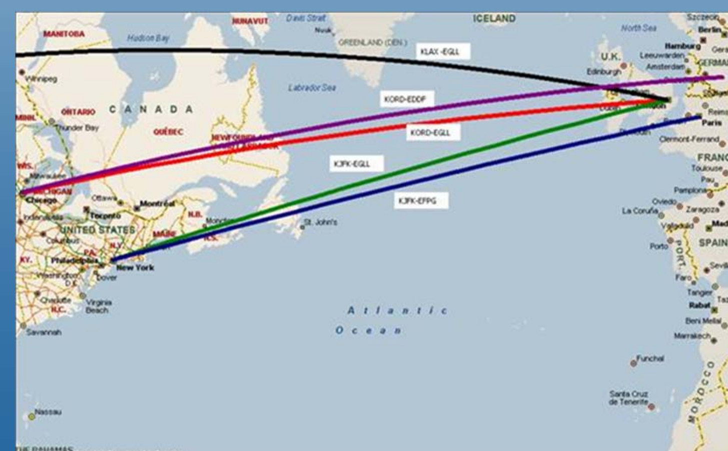
Current Separation Standards

Oceanic Operating Environment

- The Organized Track Structure (NAT OTS) is a series of parallel tracks that stretch across the NAT.
- 4 to 7 tracks are designed twice daily to take advantage of tail winds or avoid head winds for the East and Westbound flows respectively.
- Despite best efforts, it still results in an operating environment that is very structured – dynamic changes to aircraft altitude, speed are by exception.

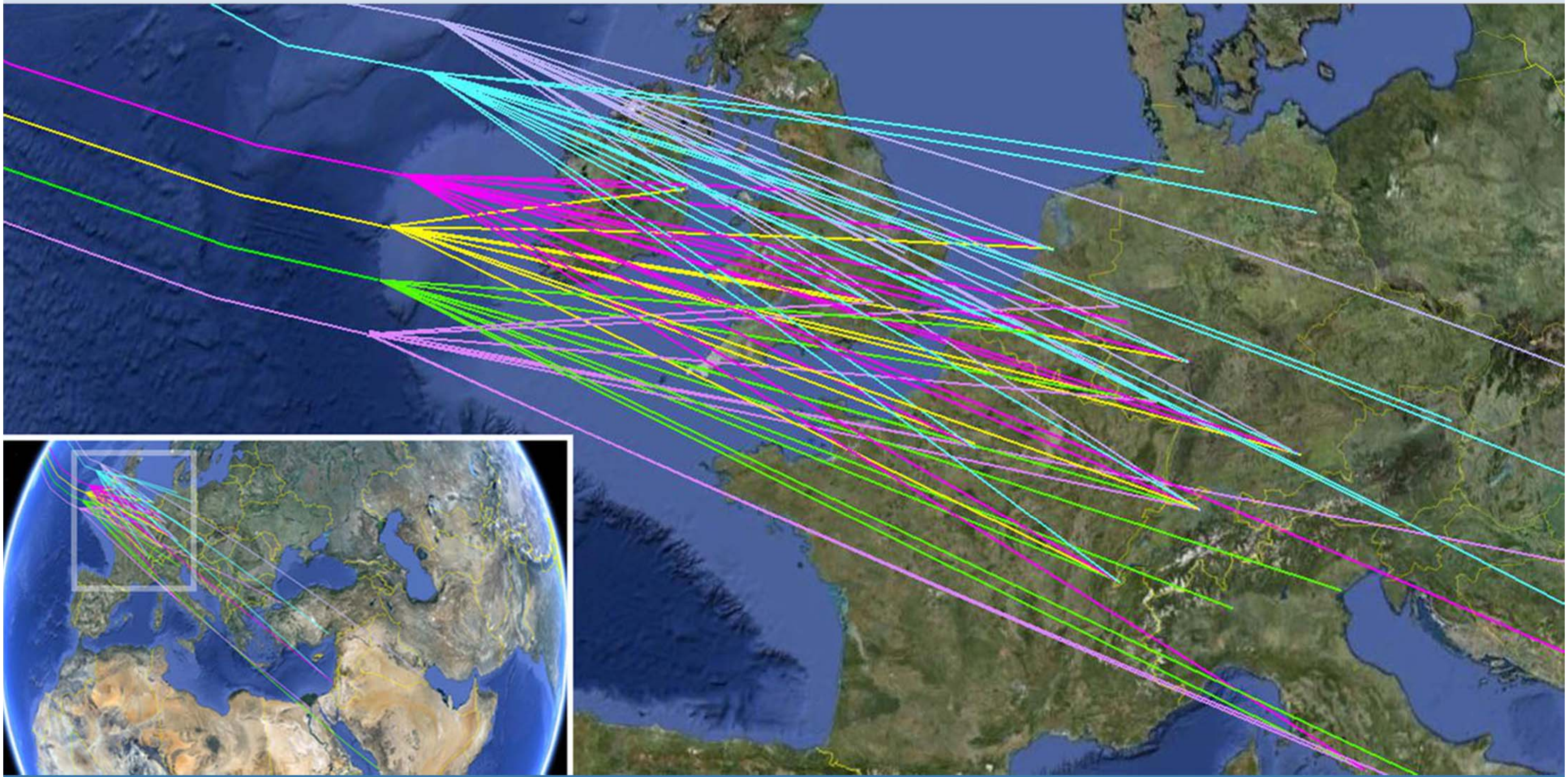


Current Track Structure



Great Circle Routes

Traffic to/from NAT OTS



The Opportunity

- The installation of ADS-B sensors on LEO satellites will enable the extension of surveillance beyond the reach of ground based systems to cover the entire globe without any additional aircraft equipage.

- Satellite ADS-B surveillance could replace the need for procedural separation standards between aircraft in oceanic and remote airspace, enhancing safety and significantly reducing flight times, and fuel burn.

Summary of technical analysis

- Stratospheric balloon experiments have been conducted carrying 1090 MHz sensors to characterize and demonstrate ability to detect signals
- ESA launched Proba V in May 2013 with ADS-B sensor
- Proba V has assessed detecting signals from 820 kms up in orbit, has successfully proved the concept
- Extensive simulations performed on spot beam geometry and probability of detection
- Interference environment analysis

Sensor payload

- Payload receivers have capability to de-garble multiple wanted/unwanted signals, due error correction capability of ADS-B PPM signal. (Probability of detection models)
- Other than reception of the ADS-B message, all data processing done at the ground network operations center.
- Design allows for capability of spot beam scan with reduced beam, also beam dwell and beam stare in target areas
- Up to 3000 targets can be processed within satellite beam
- Initial launch scheduled for June this year

Benefits Assessment

- Simulation conducted based on 1,000’ climb with up to 3 climbs per flight to enable aircraft to reach higher, more fuel efficient altitudes and increase capacity on the more fuel efficient trajectories.
- Other efficiency initiatives assumed to already be in place (RLatSM, RLongSM)
- Assessment shows average fuel savings of 450 litres per NAT flight
- Represents a conservative assumption of saving less than 2% of the oceanic portion of fuel for a transatlantic flight (450/26,000 litres)
- Significant estimated savings. Figure is for Oceanic airspace only, although benefits likely to accrue beyond

Benefits - Safety

- ADS-B via satellite will provide real time aircraft surveillance (updates no greater than 15 sec)
- Improves situational awareness, conflict detection and reaction/resolution
- Aircraft would have more flexibility in an abnormal flight situation (ACAS-ADS-B cockpit display + ATM clearance)
- Provides surveillance tracking source separate from the communications (CPDLC) network sources
- More complete and accurate reporting of aviation occurrences, allowing better management of safety risk and support of the Safety Management System

Receiver detection modelling

- Needed to model the position update interval performance requirement (meet separation standards)
- Aircraft density and other 1090 MHz in-band transmitters within the satellite beam footprints
- Satellite motion and effects on update interval performance
- Characterize expected performance in several examples in different Flight Information Regions

Ongoing Studies and RF Environment

- Ongoing studies assess the RF environment at 1090 MHz
- The co-channel interferer's are ATCRBS, IFF, Mode-S and 1090 ES ADS-B
- Currently in some high density areas 1030 interrogator activity can cause high loading resulting in garble/FRUIT
- A mix of civil interrogator and military Modes of operation (a compatible RF environment)
- Mode 4 and Mode 5 modelled same as ATCRBS

Conclusions

- No additional avionics required for aircraft above 5700 kgs (SARP'S requirement)
- ACAS and ADS-B use antenna diversity (upper and lower)
- Frequency band is globally allocated/protected under 4.10 of the ITU Radio Regulations
- No allocation for aircraft to satellite uplink, AMS(R)S required
- Annex 10 Vol IV SARP's also has limits for non civil use
- Annex 10 SARP's change will eliminate the SSR "all-call" interrogations at 1030 thus improving the 1090 reply RF environment