Implementation of ADS-B Systems

Benefits and Considerations

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What can ADS-B do for Commercial Aviation?

- Improve aircraft merging and spacing
- Support constant descent approach
- Improve cockpit situational awareness – in the air and on the ground
- Provide standalone aircraft surveillance capability in the absence of ground infrastructure
- Increase capacity to meet growing demand
- Increase on-time performance of scheduled carriers

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What can ADS-B do for ANSPs?

- Enable more cost-effective surveillance expansion
- Reduce the need for maintaining radar infrastructure
- Improve controller productivity
- Enable lower acquisition and operating costs than existing radar infrastructure
- Enable low altitude surveillance coverage
- Provide coverage in geographically challenged locations; mountainous and remote areas
- Enhance ANSP Decision Support Tools

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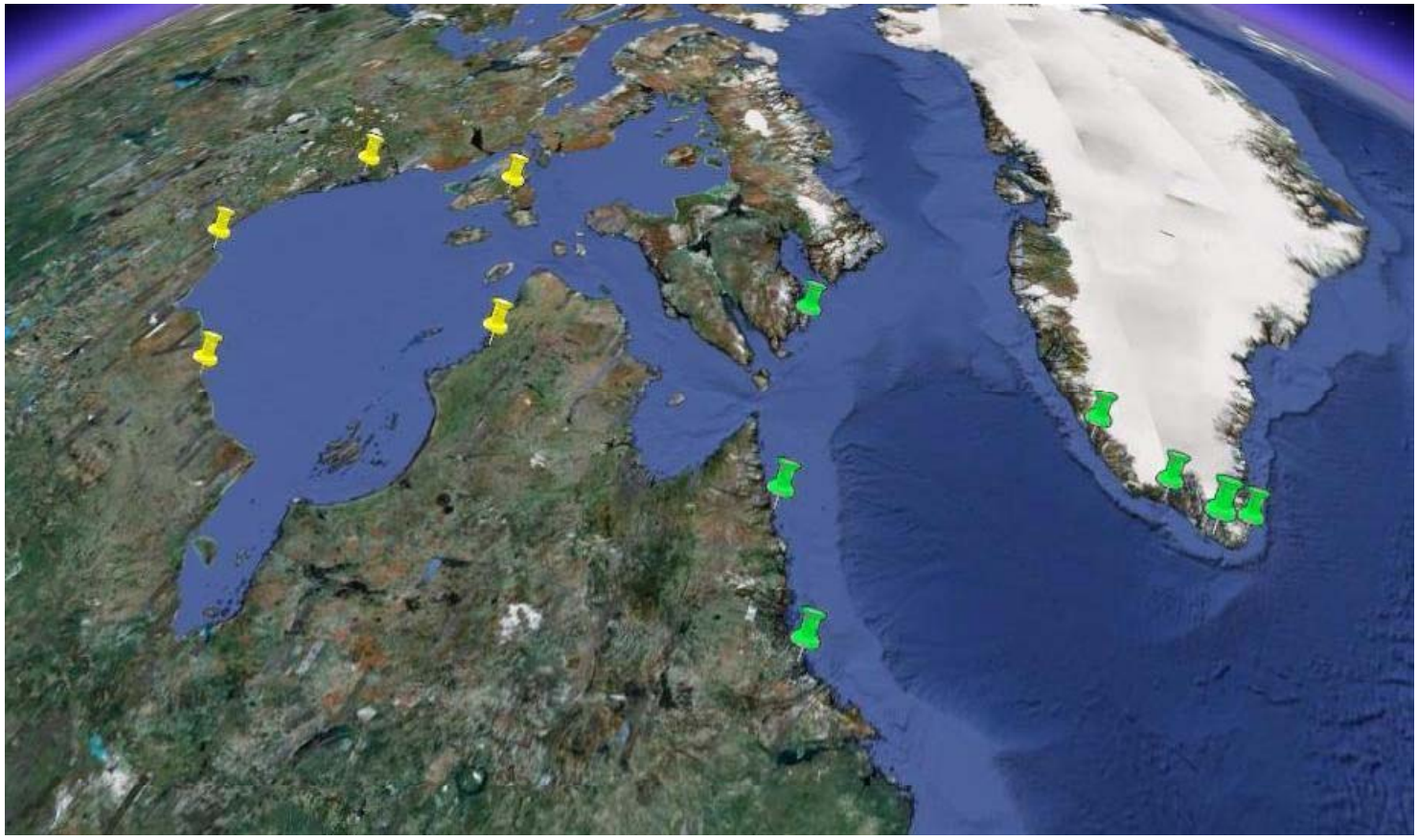
NAVCANADA deployment of Sensis ADS-B

- First two deployment phases of northern deployment complete
- Hudson Bay (yellow) and Oceanic/Greenland (green)



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NAVCANADA deployment of Sensis ADS-B

- **Phase 1: Hudson Bay**
- Issues:
  - Hudson Bay covers an area of over 250,000 sq. nmi
  - Little surveillance coverage over the Bay
  - Aircraft traversing the area require procedural separation (80 nmi – 10 minutes)
  - Longer flights, increased fuel consumption, traffic limitations
- Solutions:
  - Sensis ADS-B surveillance of airspace over Bay
  - Reduced separation to 5 nmi and preferred altitude for qualified aircraft
  - Enhanced safety

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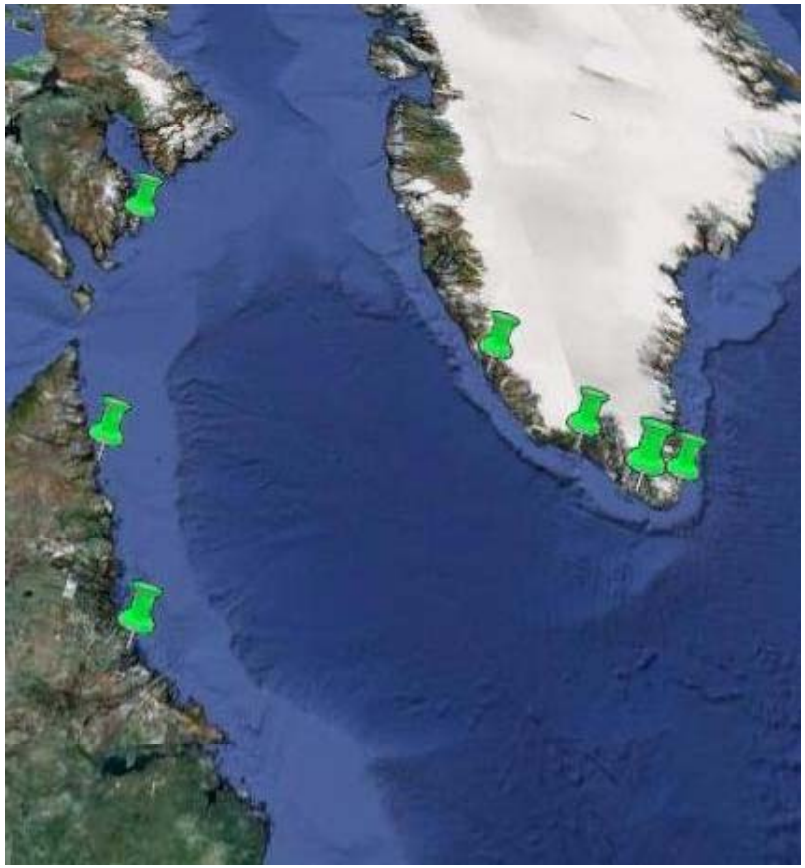
NAVCANADA deployment of Sensis ADS-B

- **Phase 2: Oceanic/Greenland**
- Issues:
  - Similar limitations to Hudson Bay
  - More Trans-Atlantic traffic than Hudson Bay
- Solutions:
  - Sensis ADS-B surveillance of airspace over North Atlantic
  - Reduced separation to 5 nmi and preferred altitude for qualified aircraft
  - Enhanced safety
  - Sites in Canada and southwest coast of Greenland



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Deployment Considerations for Hudson Bay

- Environment:
  - Severe weather
  - All sensor equipment rated for outdoor use between -40°C and 55°C
  - Weather proof enclosure
- Communications:
  - DDS (Serial)
  - Fiber
  - Satellite
  - All are used in ADS-B deployments

ADS-B Site in Hudson Bay (summer)

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ADS-B Site in Hudson Bay (winter)

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Deployment Considerations for Hudson Bay

- Performance Requirements
  - 98% Probability of Detection for a 5 second update rate (well exceeded)
  - 250 nmi coverage from each sensor (for targets in clear line of sight)
- Integrity Monitoring
  - RF site monitors deployed to monitor receive path of ADS-B sensors
  - GPS constellation integrity monitor deployed at each site
- Acceptance Testing
  - Test aircraft equipped with DGPS recorder for positional truth data
  - Test aircraft equipped with DO-260A compliant transponder
  - One week of flight trials to cover complete coverage volume

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Hudson Bay ADS-B Completion

- Hudson Bay ADS-B surveillance currently used operationally for 5 nm separation of qualified aircraft
- Sensis/Nav Canada awarded the "*Jane's Environment Award at the 2010 ATC Global Exhibition and Conference*" for the Hudson Bay deployment
  - Recognizes the contribution of the system to reducing environmental emissions
  - Nav Canada estimate: from 2009 to 2016, airlines will save $195 million in fuel and reduce greenhouse gas emissions by 547,000 metric tons

- ADS-B system for Oceanic/Greenland coverage is also operational

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General ADS-B Considerations

- Data Output format
  - Eurocontrol ASTERIX standards for ADS-B
  - Typical: Category 21 for target reports, Category 23 for ground station status
  - Specialized formats possible (custom Category 34 for status and 48 for targets developed for Nav Canada)
- Standards compliance
  - ADS-B Mandate in 2016 for Europe and 2020 for United States
  - **Ground Station**: Eurocae ED-129
  - **Software**: Eurocae ED-109/ED-153
  - **Avionics**: RTCA DO-260/A/B, ICAO
    - Ensure that continuous compliance to revised specifications supported by surveillance supplier

General ADS-B Considerations

- Legacy ATM system reliance on Mode 3/A identification
  - Some older ATM systems rely on Mode 3/A code
  - Many ADS-B transponders will not provide Mode 3/A
  - Nav Canada needed to develop new flight plan database correlated by call sign, rather than Mode 3/A
- Data Link
  - 1090 MHz Mode S Extended Squitter accepted worldwide
    - 1090 MHz used on Nav Canada deployments
  - UAT 978 MHz supported in United States
    - Sensis has supported this data link for the FAA

Sensis deployed ADS-B surveillance on the UAT data link in Juneau, Alaska for the FAA

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ADS-B Safety Considerations

- Safety Case considerations for ATC certification
  - Functional Hazard Analysis performed for Nav Canada certification
  - High probability or high severity risks required mitigation
  - Sensis Multilateration and ADS-B systems have passed safety cases in North America, Europe, Asia and Australia
- Example (1): ADS-B accuracy and equipage
  - Risks:
    - Inaccurate or no ADS-B target position reports available due to bad GPS satellite geometry or incorrectly configured avionics
    - Intentional misreporting of ADS-B position reports
    - Non-equipped aircraft
  - Mitigation:
    - Only pre-qualified avionics eligible for 5 nmi separation (qualified by Mode S address)
    - Only ADS-B targets that meet position integrity thresholds eligible for 5 nmi separation

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ADS-B Safety Considerations

- Example (2): GPS constellation integrity
  - Risks:
    - Poor ADS-B accuracy due to constellation
    - Long periods with no traffic. If GPS quality is poor, will not know until aircraft enter coverage volume
  - Mitigation:
    - GPS integrity monitors co-located with each ground station
    - Quality figure for GPS constellation output to ATM system
    - Procedural separation used in the event of poor GPS constellation integrity

GPS Receiver used for Integrity Monitor

- Example (3): Duplicated ICAO 24 bit Mode S addresses
  - Risks:
    - Safety critical situation if transponder identifications are duplicated
  - Mitigation:
    - Sensis ADS-B system detects, tracks and identifies duplicated IDs

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Additional ADS-B Considerations

- Backup to ADS-B systems
  - Wide Area or Surface multilateration is a viable backup to ADS-B
  - Verification of ADS-B positional data
  - Full secondary surveillance coverage while equipage is not 100%
  - Sensis uses the same sensor for ADS-B and multilateration, so any ADS-B system can be used for multilateration, with the appropriate number of sensors.

Area covered by Sensis Wide Area, PRM and ADS-B surveillance in Sydney, Australia

Sensis Surface MLAT, SMR and A-SMGCS also used at Sydney International Airport

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Questions?

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