Using Automatic Dependent Surveillance-Broadcast Data for Monitoring Aircraft Altimetry System Error

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Highlights from the Federal Aviation Administration's Support of the National Airspace System

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The World's Forum for Aerospace Leadership

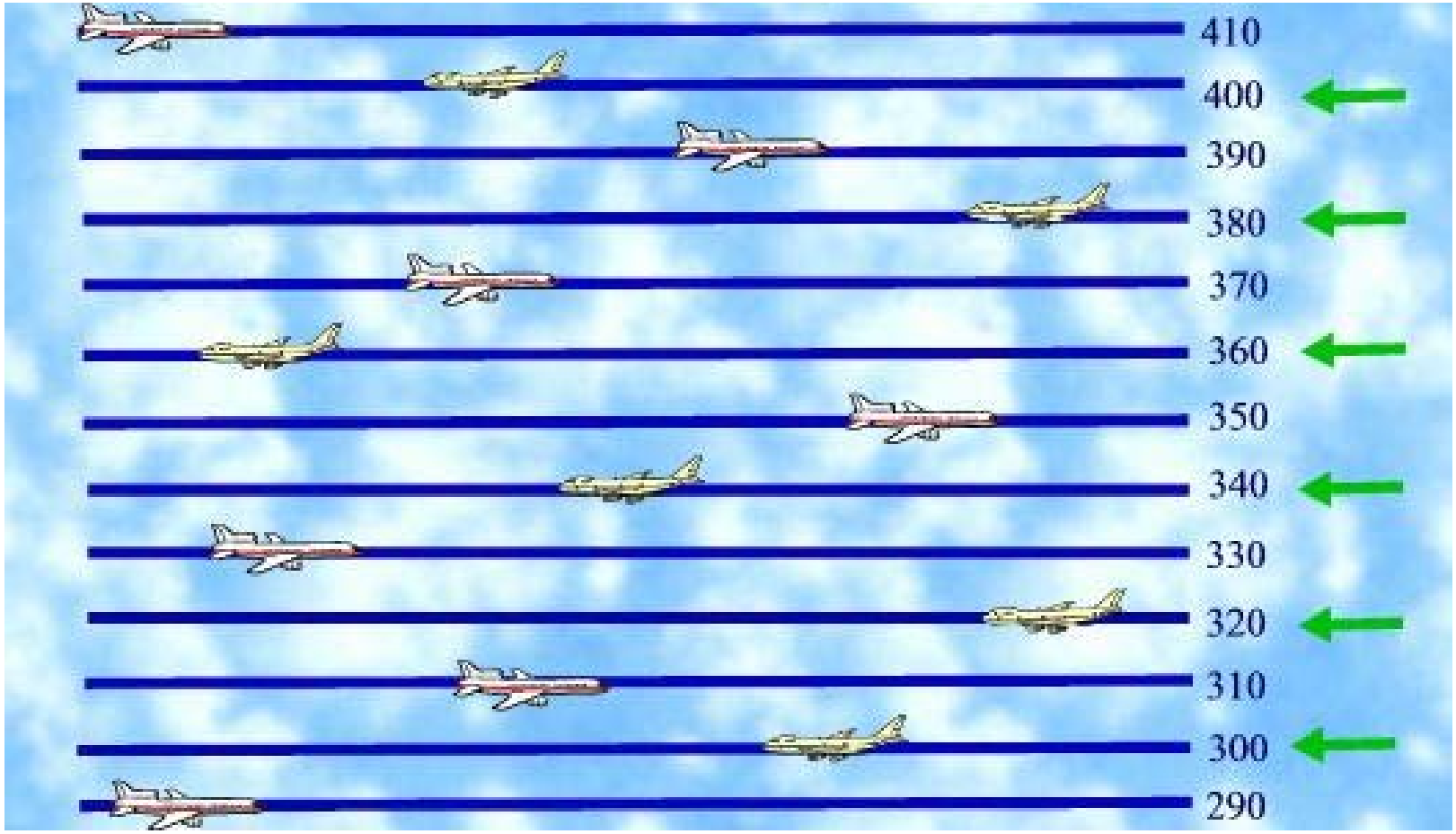
Overview

- Introduction
  - Background Information
- Objectives
- Data Sources
- Methodology
- Analysis and Results
- Conclusion
- Future Work

Introduction – Progress Work

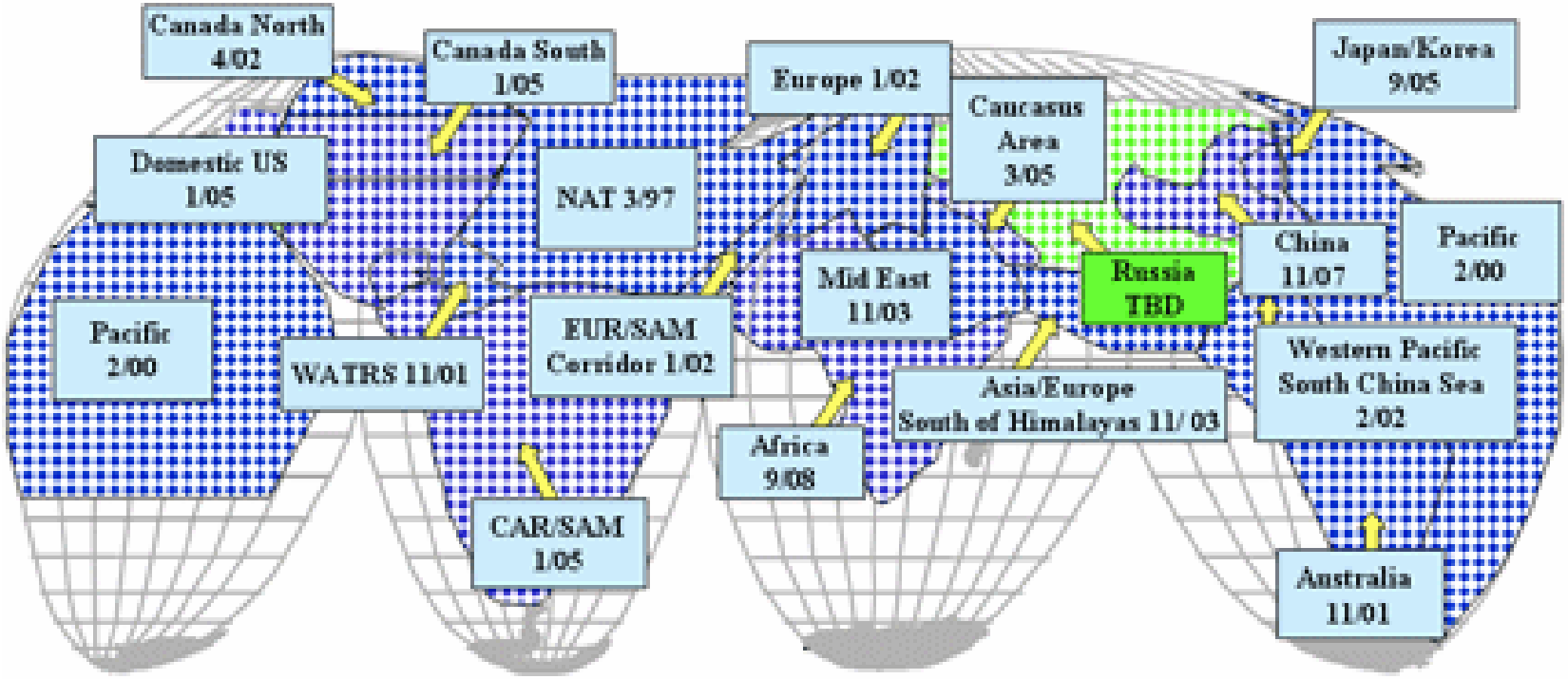
- Investigation Into the Use of Automatic Dependent Surveillance-Broadcast Data for Monitoring Aircraft Altimetry System Error
  - Lauren Martin, Christine Gerhardt-Falk, Jose Perez
  - AIAA-2008-7146
  - AIAA Guidance, Navigation and Control Conference and Exhibit, Honolulu, Hawaii, August 18-21, 2008

Reduce Vertical Separation Minimum (RVSM)



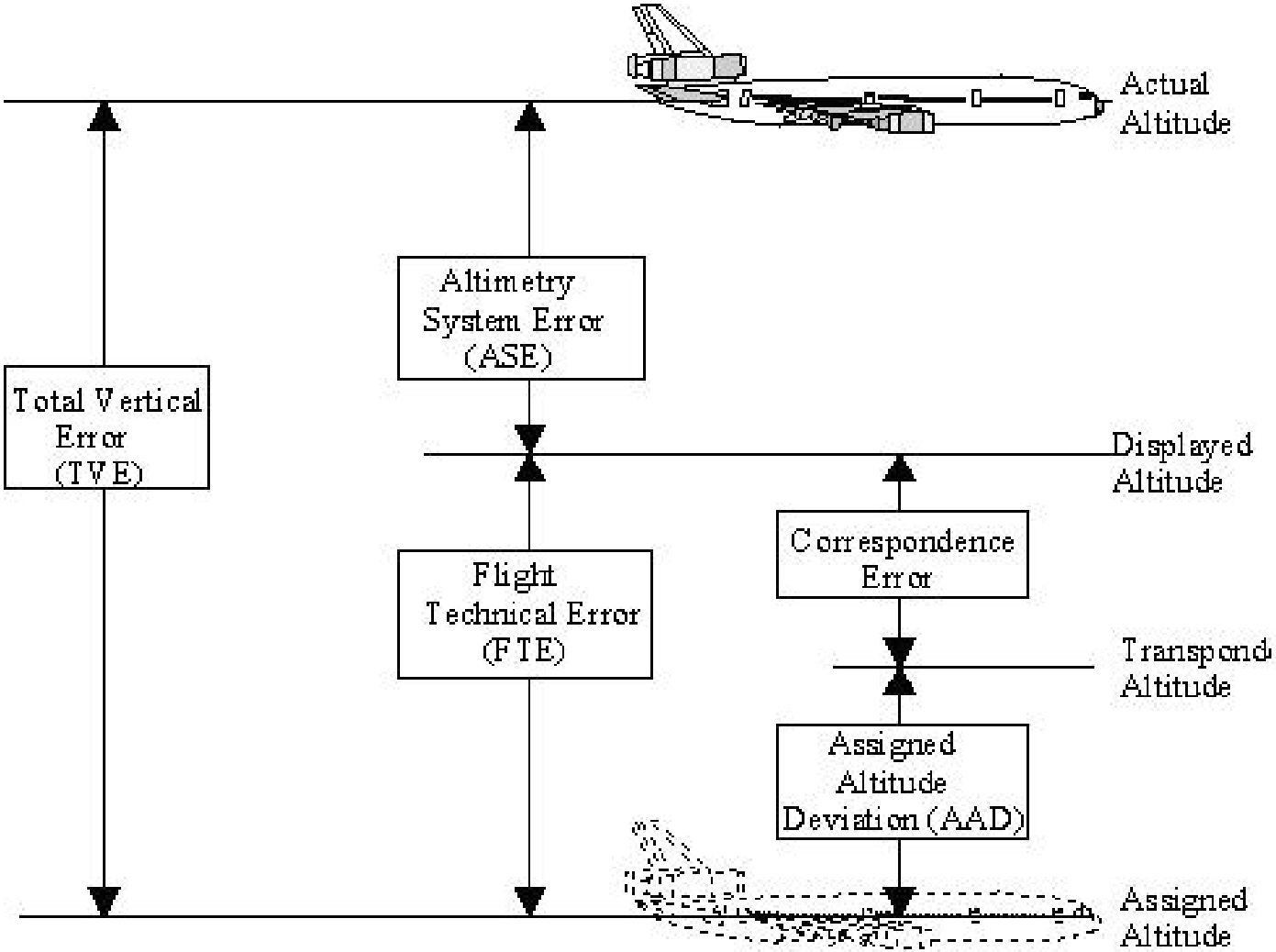
- Reduced aircraft separation from 2,000 ft to 1,000 ft.
- Allow more aircraft between flight levels 290 and 410 inclusive.

RVSM is global



RVSM Implementation Map. Implemented Planned

Altimetry System Error (ASE)



Components of Total Vertical Error (TVE)

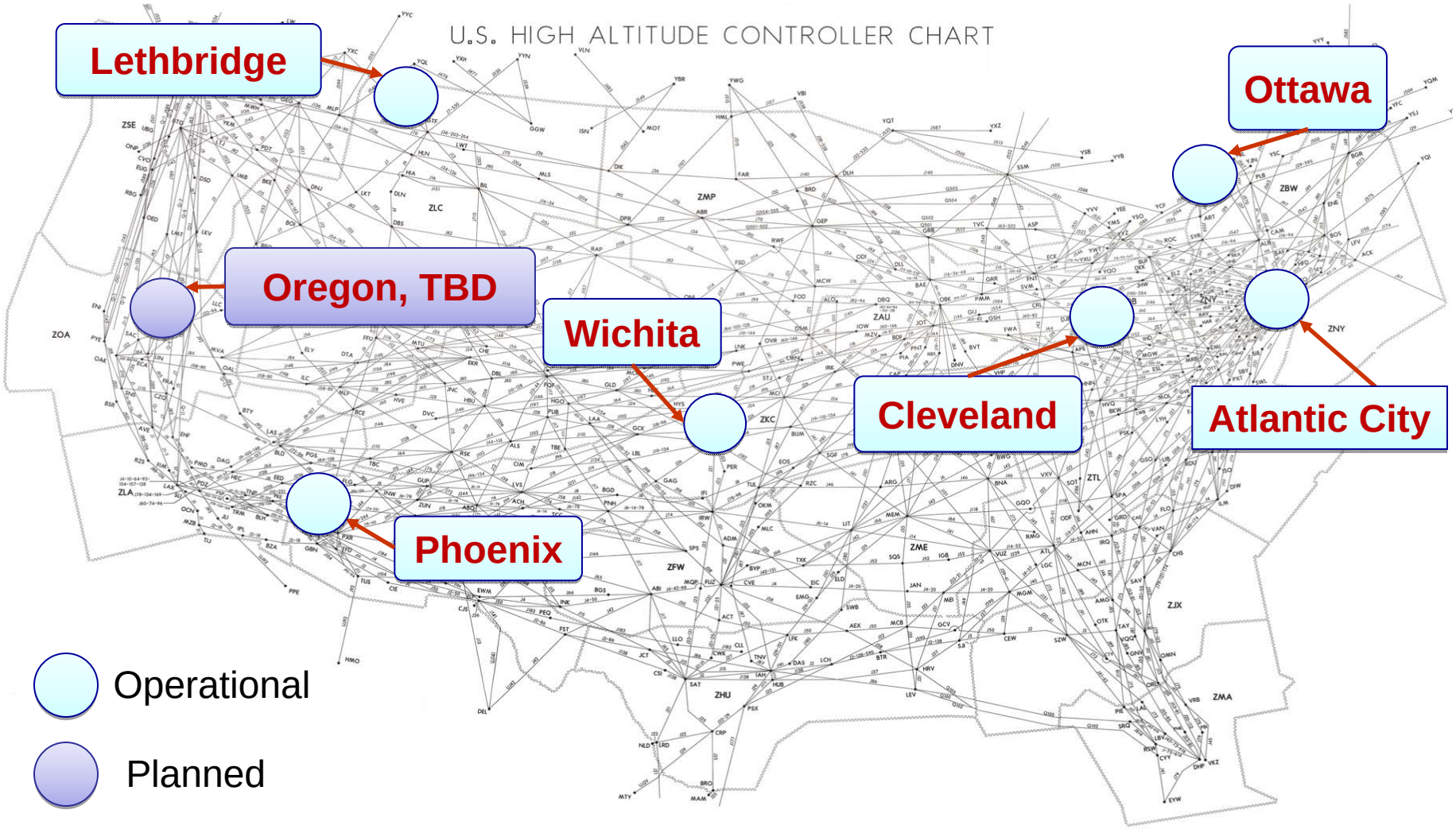
Definition of (ASE)

- Measure of the Altimetry System's ability to correctly evaluate and convert ambient static pressure.
- Is hidden from the pilot and air traffic controllers.
- There is no instruments to detect this type of error.

Aircraft ASE Measurements

- Enhanced GPS Measurement Unit (EGMU)
- Height Monitoring Units (HMU)
- Aircraft Geometric Height Measurement Elements (AGHME)
- Automatic Dependent Surveillance-Broadcast (ADS-B)

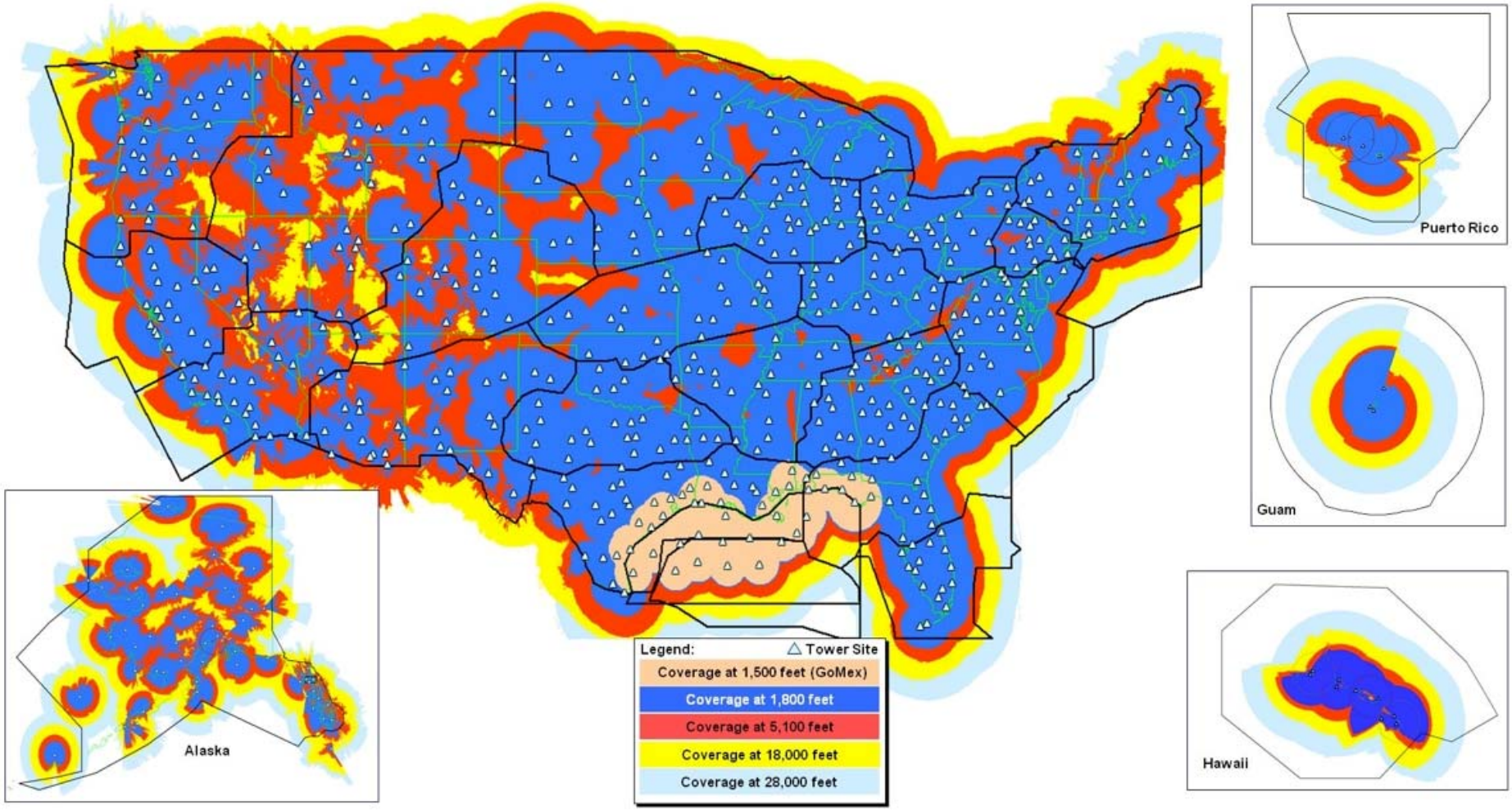
AGHME Locations



Automatic Dependent Surveillance- Broadcast

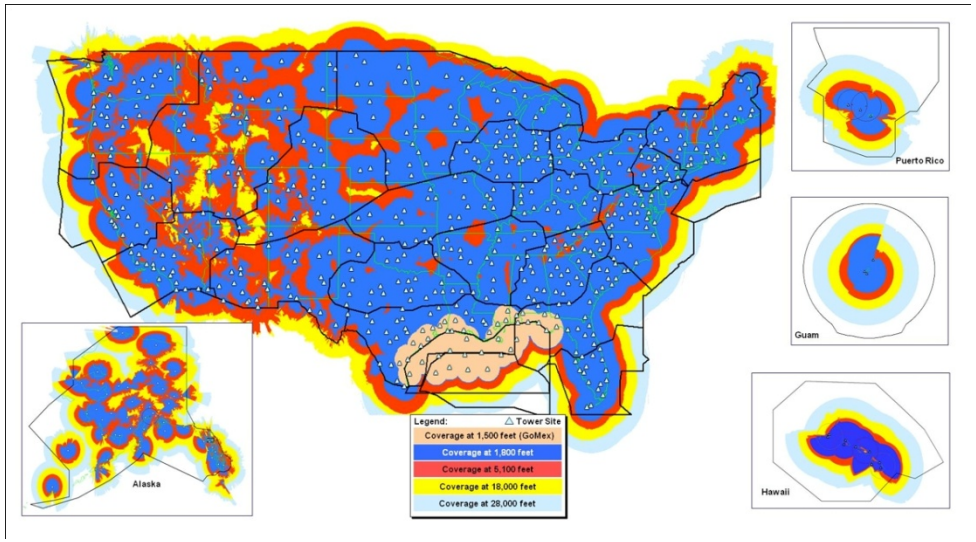
- Automatic
  - Periodically transmits information with no pilot or operator input required.
- Dependent
  - Position and velocity vector are derived from the Global Positioning System (GPS) or a Flight Management System.
- Surveillance
  - A method of determining position of aircraft, vehicles, or others.
- Broadcast
  - Transmitted information available to anyone with the appropriate receiving equipment.

ADS-B Coverage (2013)



ADS-B Challenges

- ADS-B Messages are not differentially corrected
- Wide Area Augmentation System (WAAS)
  - Air navigation aid developed by the FAA
  - Improve the GPS position accuracy, integrity, and availability
  - Only covers the United States



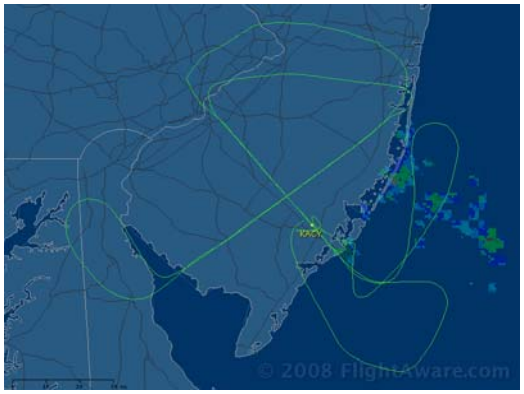
Objectives

1. Determine if ADS-B geometric height data is sufficiently accurate to estimate Altimetry System Error under uncontrolled conditions.

2. Determine if additional processing and quality control procedures are needed to utilize the geometric heights recorded in the ADS-B data.

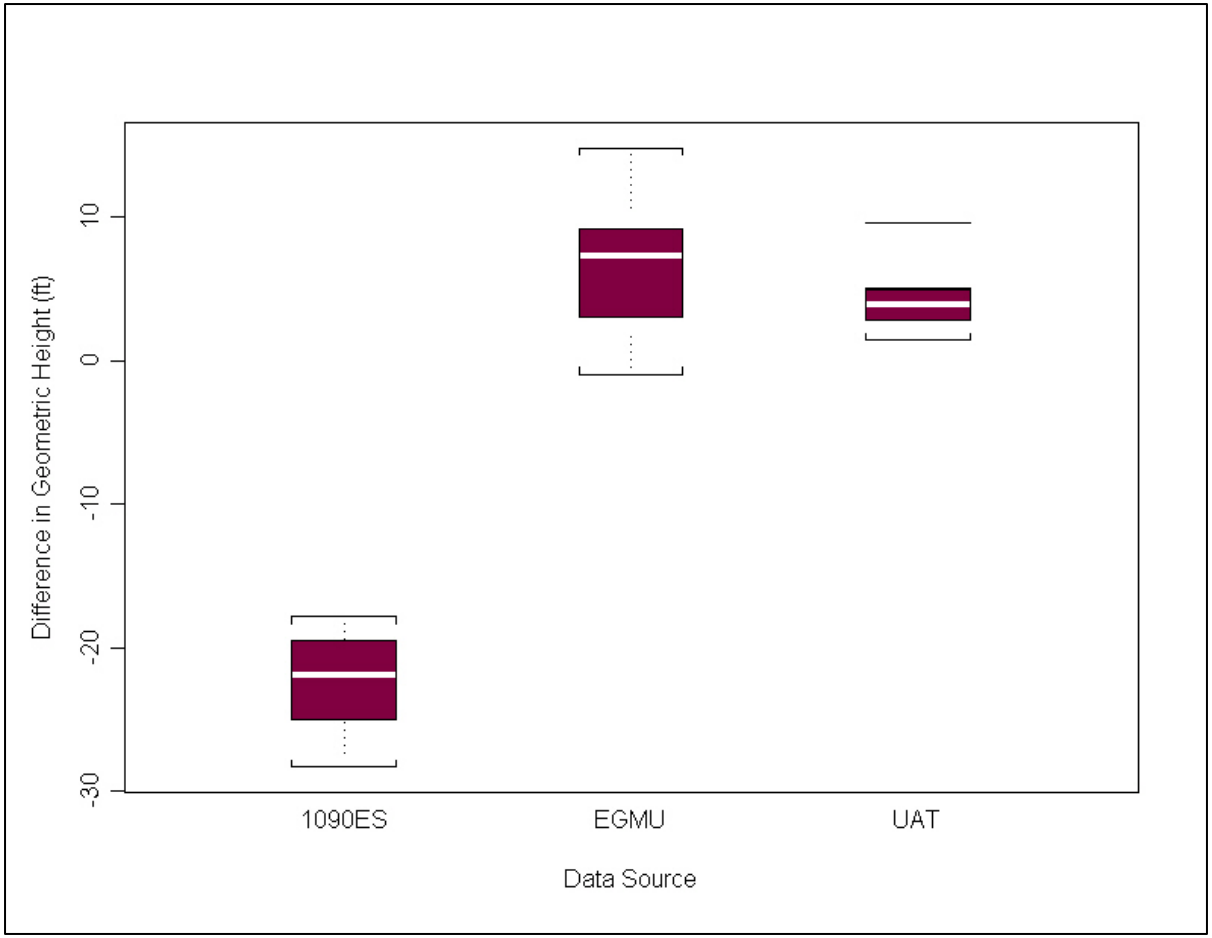
Data Source: ADS-B

- Test Flights
  - FAA Technical Center has a fleet of research aircraft that are used for conducting tests and evaluations of avionics systems
  - N47 – a Bombardier BD-700-1A11 aircraft was used for this study



  - All taking off from and returning to the Atlantic City International Airport

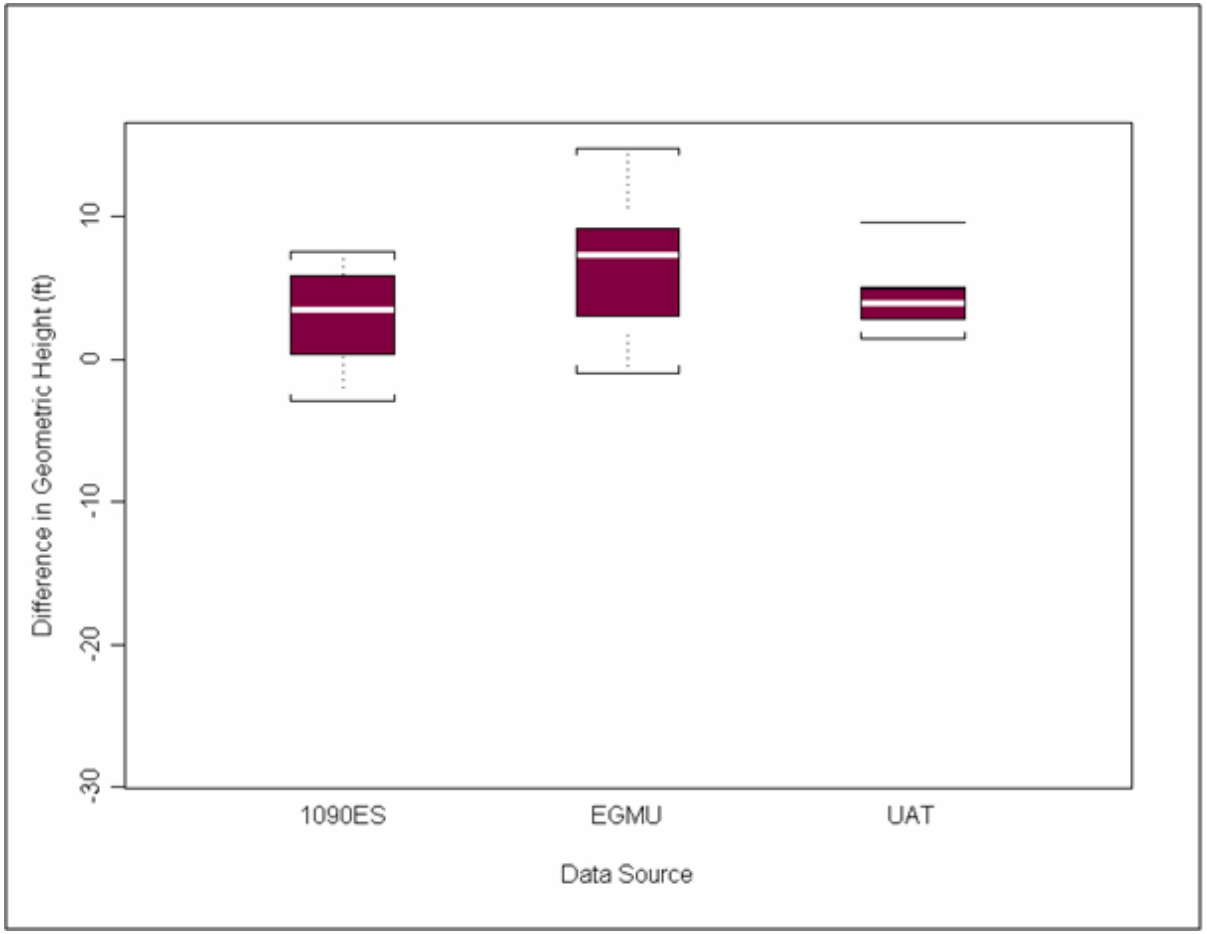
UAT WAAS vs 1090 ES WAAS



Data Source	Avg. Diff in Geometric Height
1090 ES	-22.419
EGMU	6.623
UAT	4.303

- 1090 Extended Squitter
- Enhanced GPS Measurement Unit (EGMU)
- Universal Access Transceiver (UAT)

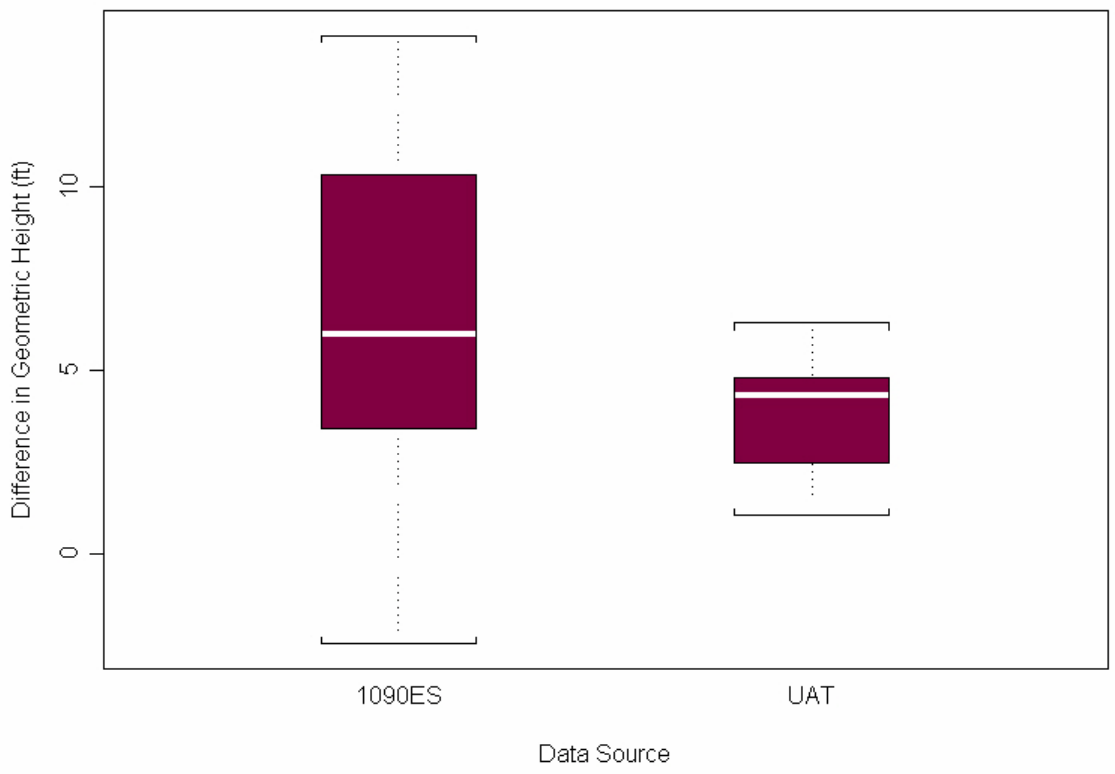
UAT WAAS vs 1090 ES WAAS



Data Source	Avg. Diff in Geometric Height
1090 ES	2.581
EGMU	6.623
UAT	4.303

- 1090 Extended Squitter
- Enhanced GPS Measurement Unit (EGMU)
- Universal Access Transceiver (UAT)

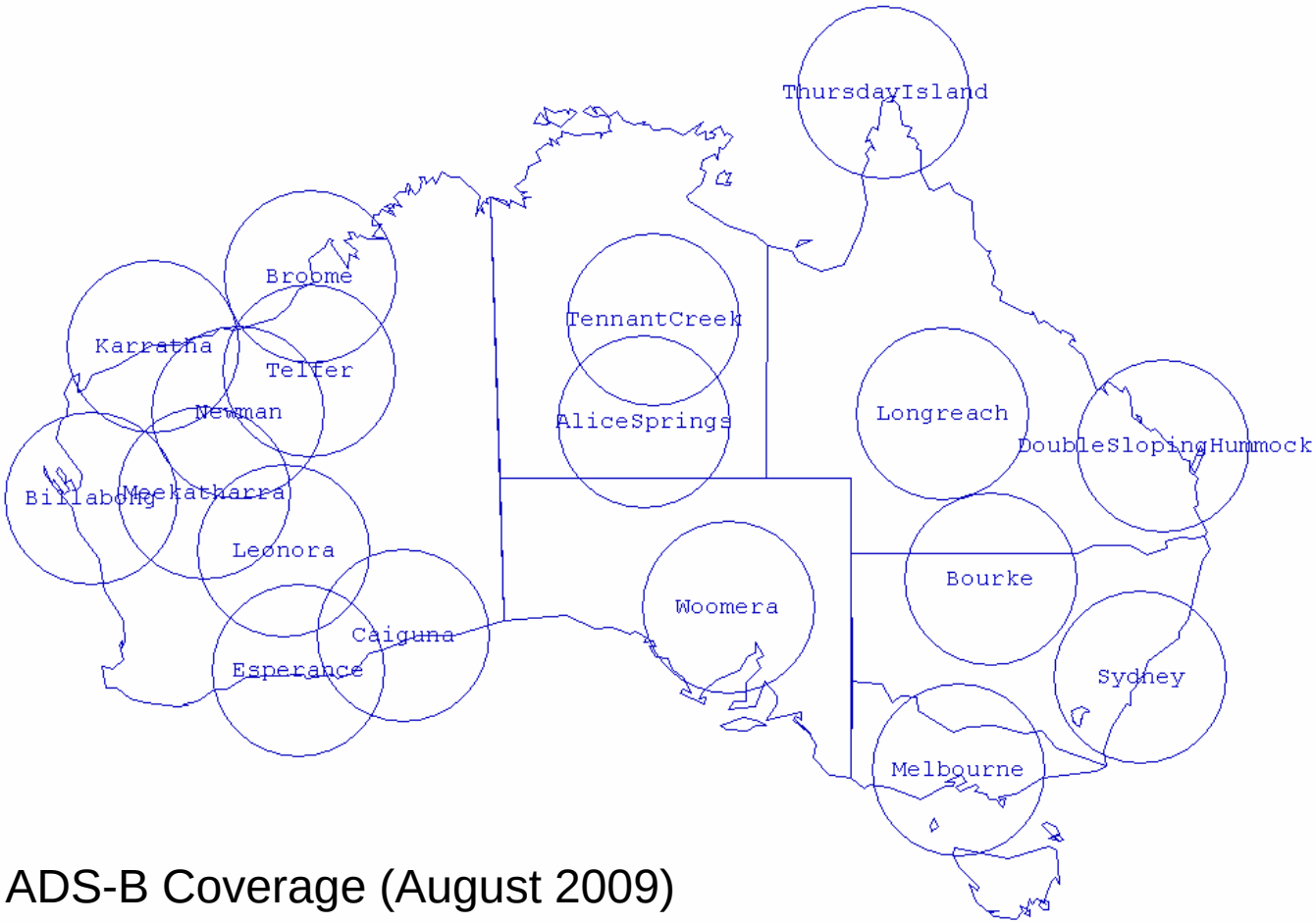
UAT WAAS vs 1090 ES No WAAS



Data Source	Geometric Height Data Range
1090 ES	**16.604**
UAT	**5.238**

- 1090 Extended Squitter
- Universal Access Transceiver (UAT)

Data Source: ADS-B (109 ES, Australia)



ADS-B Coverage (August 2009)

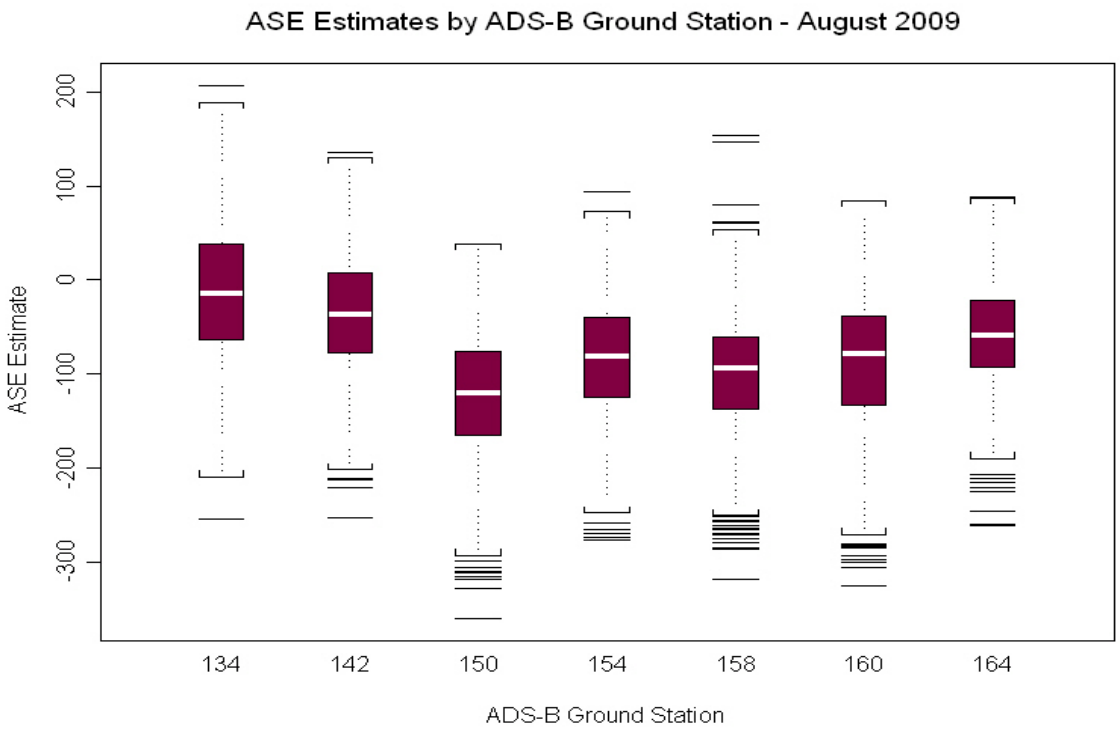
Data Source: Met Data

- Meteorological Data
  - United States National Oceanic and Atmospheric Administration (NOAA)
  - Radiosonde, satellites, and ground stations
  - 0000, 0600, 1200, 1800 UTC
  - 100, 150, 200, 250, 300, 400, 500, 600, 850, and 1000 mbar
  - 1.25 degrees latitude by 1.25 degrees longitude

Methodology

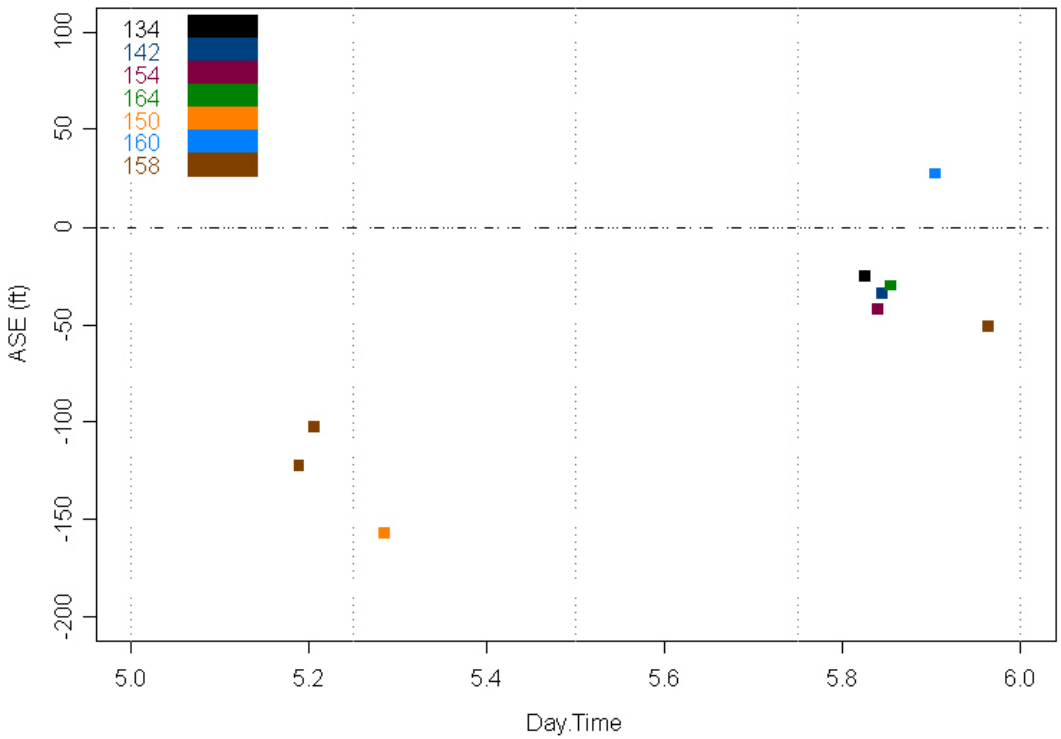
- Automated ASE software
  - Support large amount of data obtained from ADS-B
  - Identification of unique straight and flight level
  - Smooth aircraft geometric heights
  - Combine geometric heights with meteorological data
- Treatment of the Level Flight Segments
  - Four minute minimum segments length
  - Only flight levels between 290 and 410 inclusive
- Treatment of the Resulting Aircraft ASE
  - ASE range up to 100 ft

Analysis and Results By Ground Stations



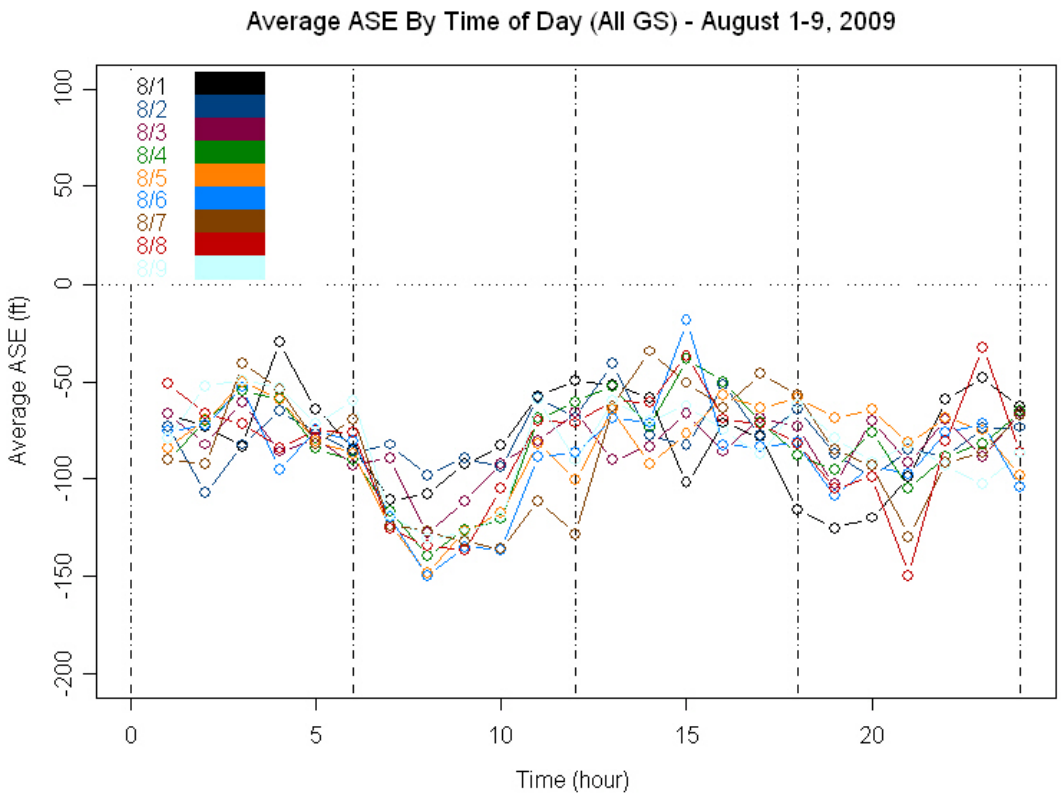
– There are significant differences in the ASE estimates
  - Individual airframes
  - Meteorological data variation

Analysis and Results By Unique Aircrafts



– 18 unique aircraft observed by all 7 ADS-B stations
  - Meteorological data vs Geometric Height Data

Analysis and Results By Time of Day



- Displacement of the Average ASE by Time of Day.
- Pattern consistent for all sites.

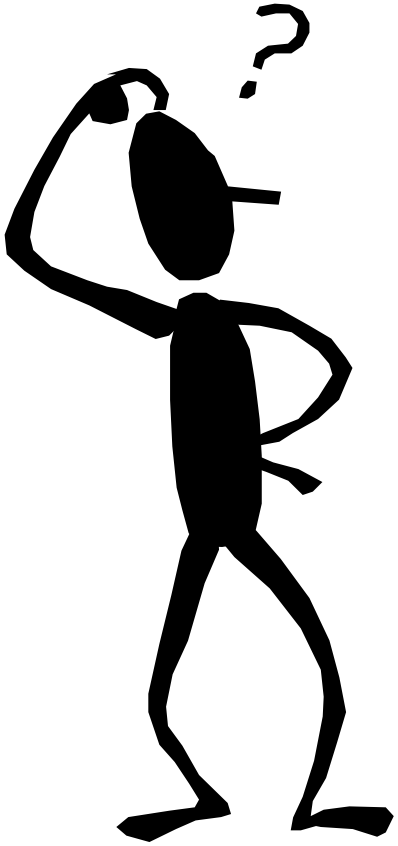
Conclusions

- US ADS-B with and without WAAS corrections
  - Sufficiently accurate to estimate aircraft ASE under uncontrolled conditions.
  - 1090 ES apparent biased was false.

- Airservices Australia ADS-B
  - Additional processing and quality control is needed.
  - It appears to be a bias in the ASE results obtained.

Future Work

- Meteorological Data
  - Alternate sources.
  - Frequent updates instead of 6 hours increments.
- Validation and verification
  - ASE results for specific airframes and aircraft groups with other monitoring sources.

Contact Information

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