



Altimetry System Error (ASE) Data Introduction to Discussions

FAA ANG-E61



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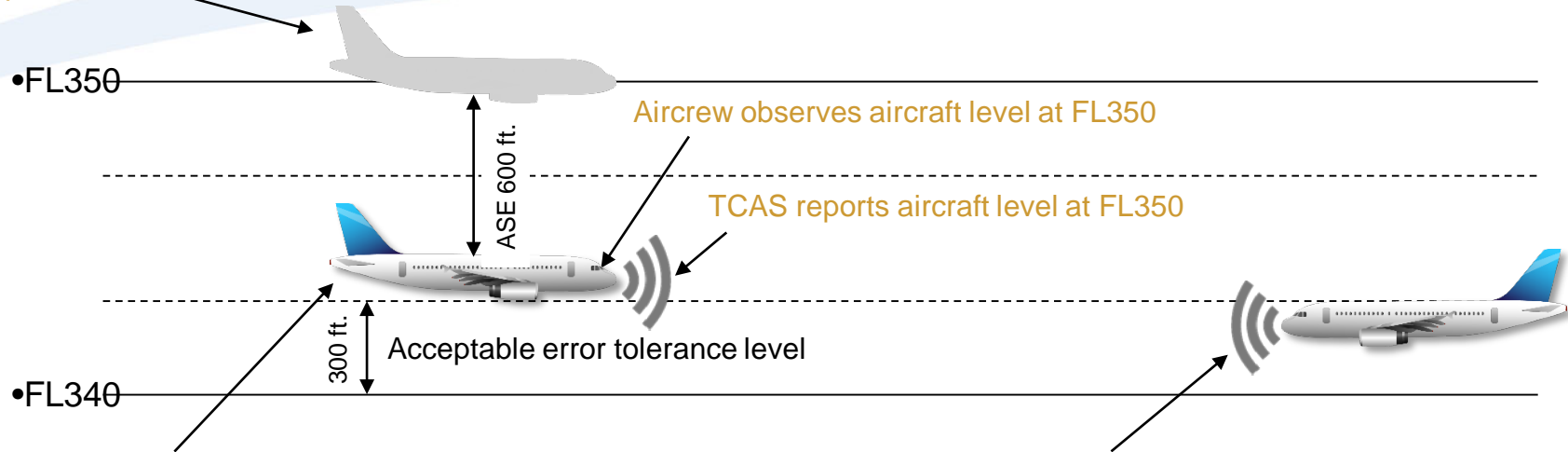
Federal Aviation
Administration

Topics for Discussion

- Data Elements
- Monitoring Methods
- Meteorological Analysis
- ASE Results Processing
- RVSM Approval Database

Altimetry System Error (ASE) Risk

Aircraft presumed level at FL350



Actual aircraft position in relation to observed FL – FL344

TCAS observes aircraft level at FL350

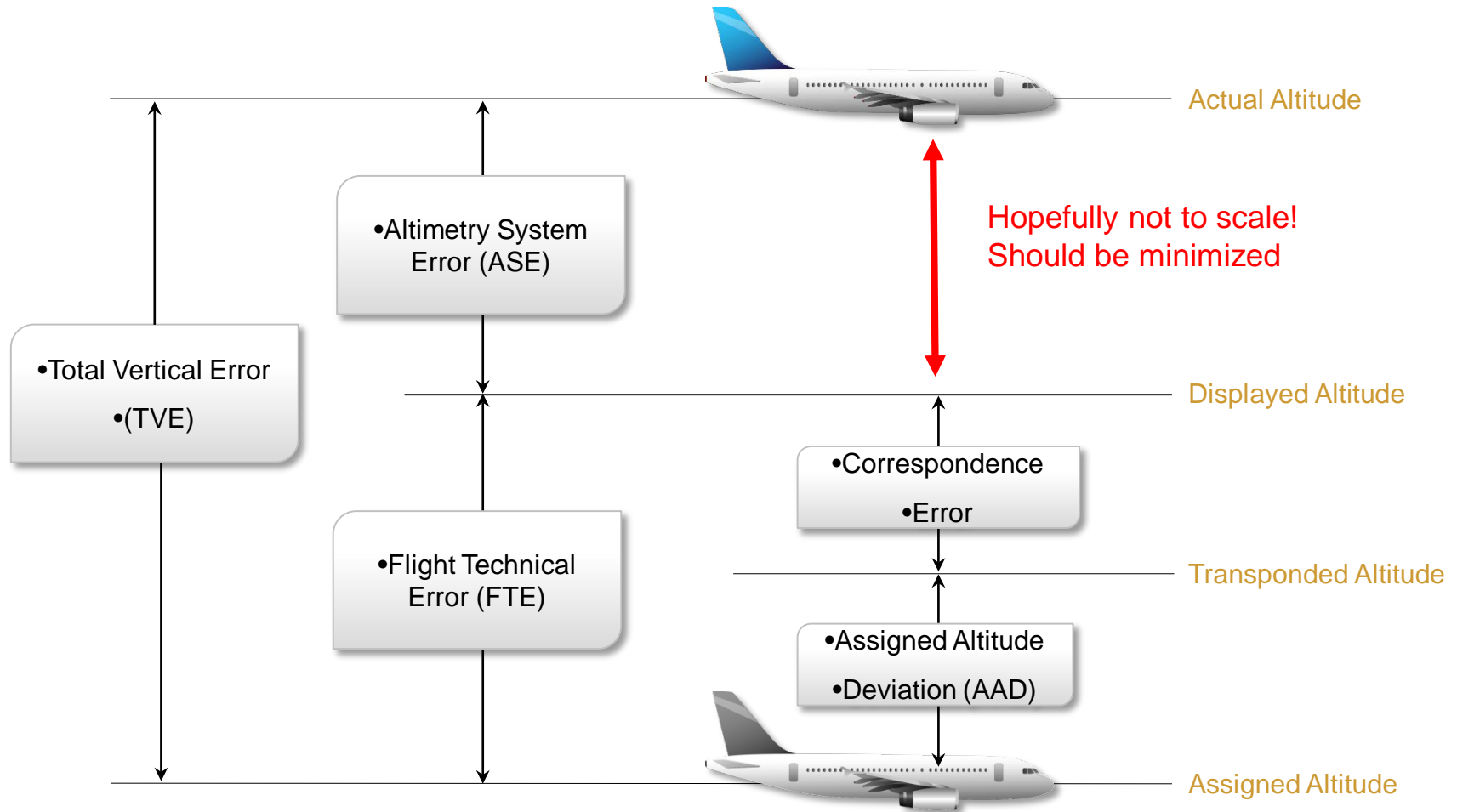


✓ Datablock indicates aircraft is level at FL350

- ASE is undetectable by aircrew, TCAS and ATC and has a marked effect on risk.

✓ ATC Observes Aircraft Level At FL350

Elements of Vertical Error



Elements of Total Vertical Error

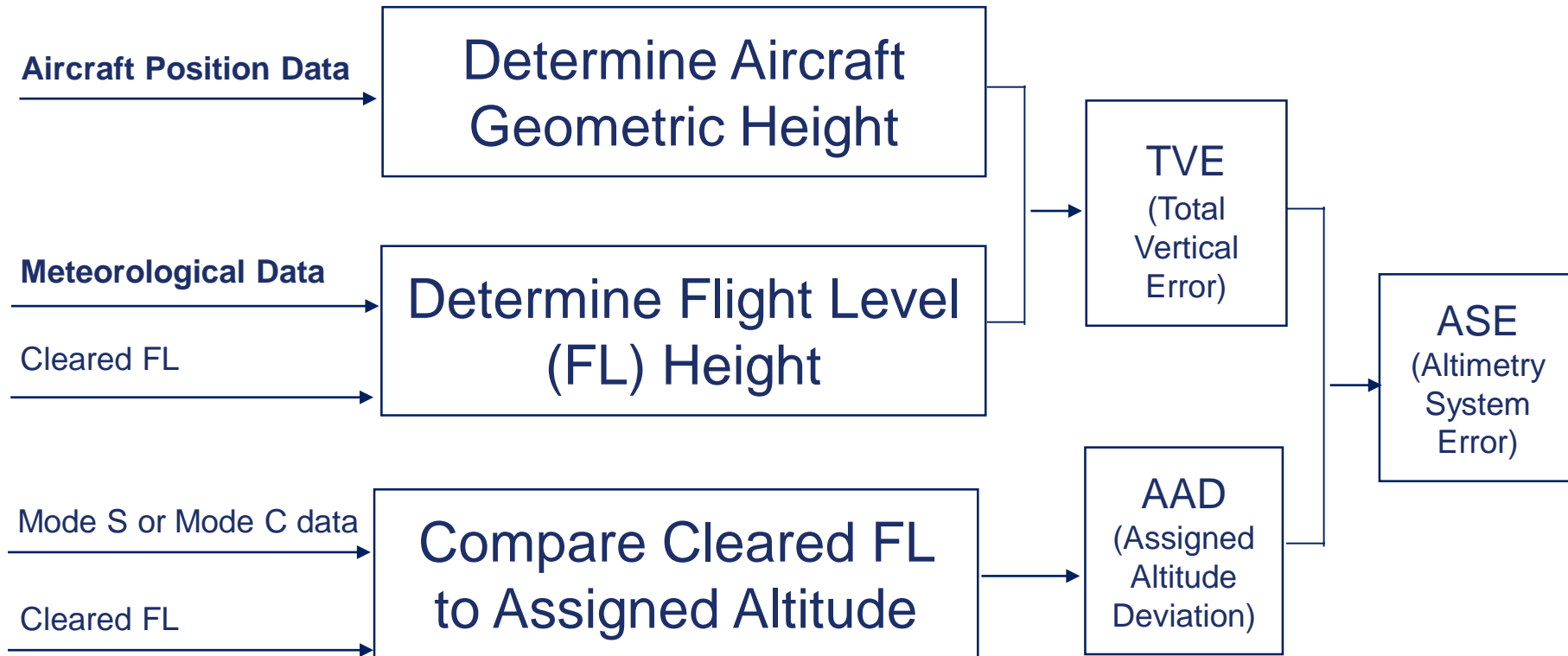
- Total Vertical Error
 - ✦ Where an aircraft is in reference to the pressure altitude of the assigned flight level
- Displayed Altitude
 - ✦ What the aircrew sees on the altimeter
- Transponded Altitude
 - ✦ Displayed altitude quantized (25 ft Mode S; 100 ft Mode C) is what TCAS and ATC see
- Altimetry System Error
 - ✦ Instrumentation error of the static source aircraft reference system is not typically seen unless using special instrumentation



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Altimetry System Error Calculation Process



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MONITORING METHODS



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Altimetry System Error (ASE) Process

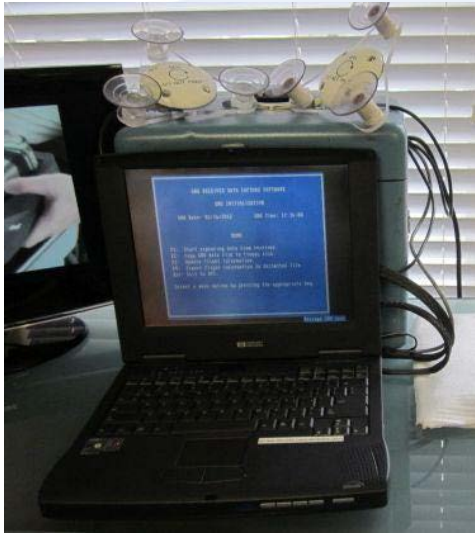
- ASE is determined by comparing the identified true height of the aircraft and the true height of the barometric pressure surface associated with the altimetry measurement
- Height keeping performance of an aircraft is measured by equipment independent of the aircraft's altimetry system:
 - ✦ **GPS-based Monitoring Units (GMUs)**, a portable device brought on board and operated by trained technicians – This method uses GPS data to collect the aircraft's position that is then used in the ASE process.
 - ✦ **Ground-based Height Measuring Units (HMUs)** such as the FAA Aircraft Geometric Height Measuring Elements (AGHMEs) - true altitude is measured by the AGHME multilateration techniques
 - ✦ **Automatic Dependent Surveillance-Broadcast (ADS-B) Height Monitoring System (AHMS)** - provides a source of aircraft position data for use in the ASE calculations.

Portable Monitoring System

GPS-Based Monitoring Unit (GMU)

- The GMU is a special-purpose data collection system carried aboard an aircraft, during which the unit collects Global Positioning System (GPS) pseudo ranges.
- Post-flight processing of these data ensures estimates of aircraft geometric height which are of sufficient accuracy to permit estimation of relevant height-keeping performance parameters. In parallel, the current-generation FAA GMU also collects secondary surveillance radar Mode C data, which also contributes to parameter estimation.
- The GMU has been in use since 1996 and has been used by thousands of operators to satisfy monitoring requirements associated with the State RVSM approval process.

Generations of GMUs



GPS Monitoring Unit
GMU – 1995



Enhanced GPS Monitoring Unit
EGMU - 2003



Enhanced² GPS
Monitoring Unit
E²GMU - 2013

Total Number of GMU Monitorings as of today ??

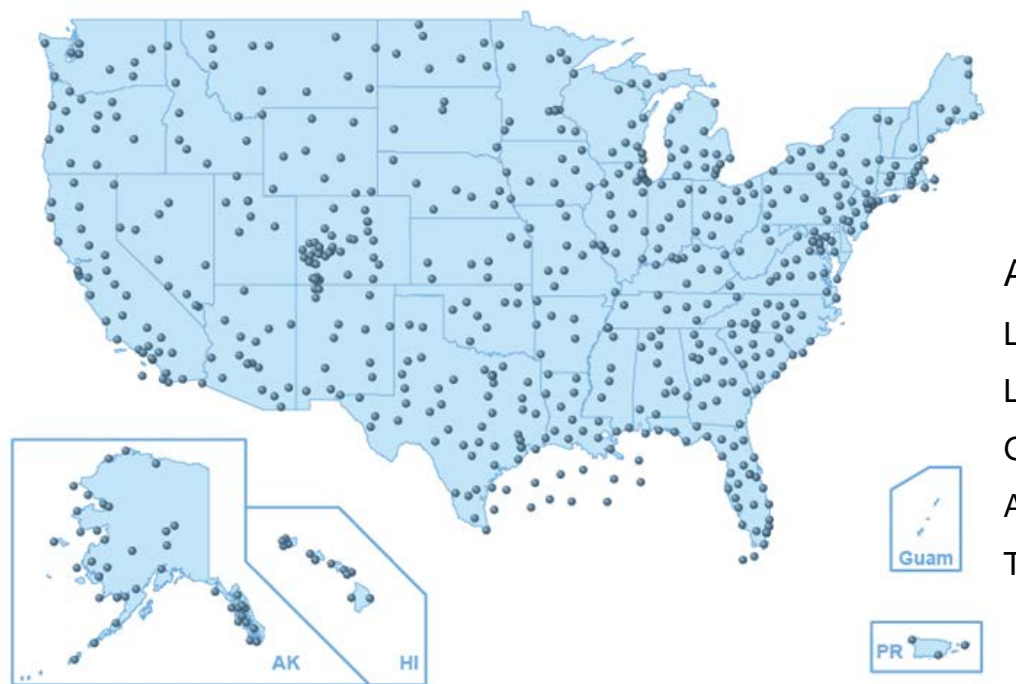
Ground Based Monitoring Systems:

Aircraft Geometric Height Measurement Element (AGHME)

- The William J. Hughes Technical Center has developed the ground-based Aircraft Geometric Height Measurement Element (AGHME) system as the principal means of satisfying one of the objectives of monitoring in connection with the North American RVSM.
- These systems are positioned at fixed locations in the United States and Canada, automatically producing estimates of the geometric height of suitably equipped aircraft flying within the coverage area of an AGHME constellation.
- Although intended to examine aggregate height-keeping performance, the AGHME system is entirely suited for the individual-aircraft monitoring which operators must complete as a part of the State RVSM approval process -- provided that the requirements for AGHME use are satisfied.

Ground Based Monitoring Systems

ADS-B Height Monitoring



ADS-B Coverage Map

ADS-B Fields

Latitude

Longitude

Geometric Height

Altitude

Time

Mode S Address

Ground Station

Flight Identification

Navigation Accuracy Category

2012 – July 2017 Data Sample for only DO-260B Airframes

Designated RMA	State	Total 1090ES DO-260B Airframes (Version 2)
NAARMO	Canada	136
	Mexico	68
	United States	3599



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METEOROLOGICAL ANALYSIS



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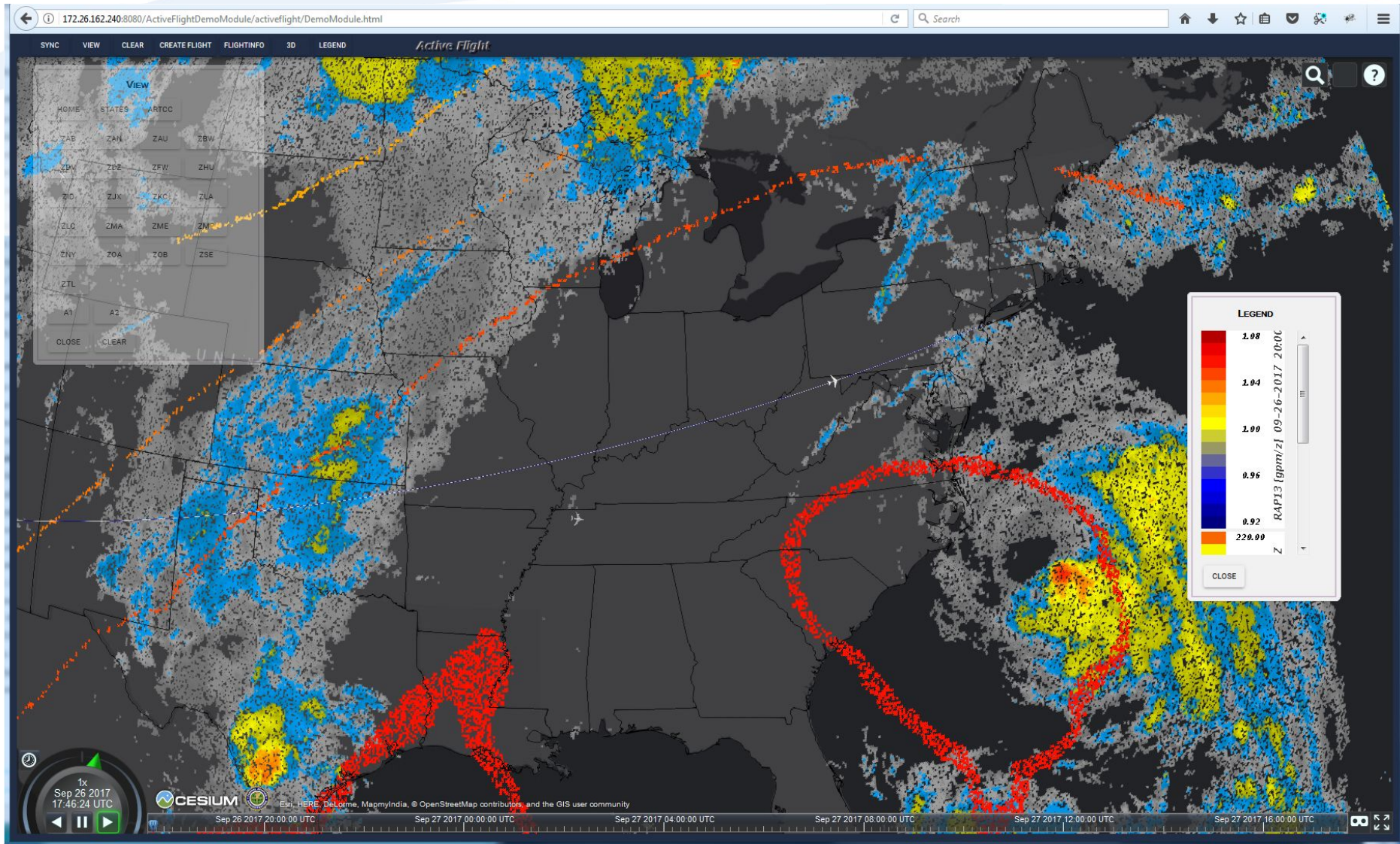
Meteorological Data (MET) Process

- Available Meteorological (MET) data is downloaded daily from the National Weather Service
- MET data is processed by the ANG-E61 software tools using accepted models to determine the true altitude of barometric pressure surfaces
- Additional automated processing matches a modeled pressure altitude surface with the location of an aircraft for ASE calculation

Meteorological Data Description (Data Source is NOAA)

- To determine flight level height for the calculation of ASE, the FAA uses meteorological data from NOAA / NWS / NCEP / EMC (National Oceanic and Atmospheric Administration / National Weather Service / National Centers for Environmental Prediction / Environmental Modeling Center)
 - ✦ The EMC is one of nine National Centers for Environmental Prediction
 - ✦ The FAA uses the WAFS (Wide Area Forecast System) meteorological data file
 - ✦ The WAFS file is derived from the NCEP GFS (Global Forecast System)
- The atmospheric forecast model the GFS uses is the GSM (Global Spectral Model) with spherical harmonic basis functions
 - ✦ The initial conditions the GSM uses is from the NCEP GDAS (Global Data Assimilation System)
- The GDAS uses all satellite, conventional, and radar observations within a plus or minus 3 hour window of the analysis time
- The NCEP Unified Post Processor (UPP) compares and verifies all model output

Potential Issues for MET Match



ASE RESULTS PROCESSING



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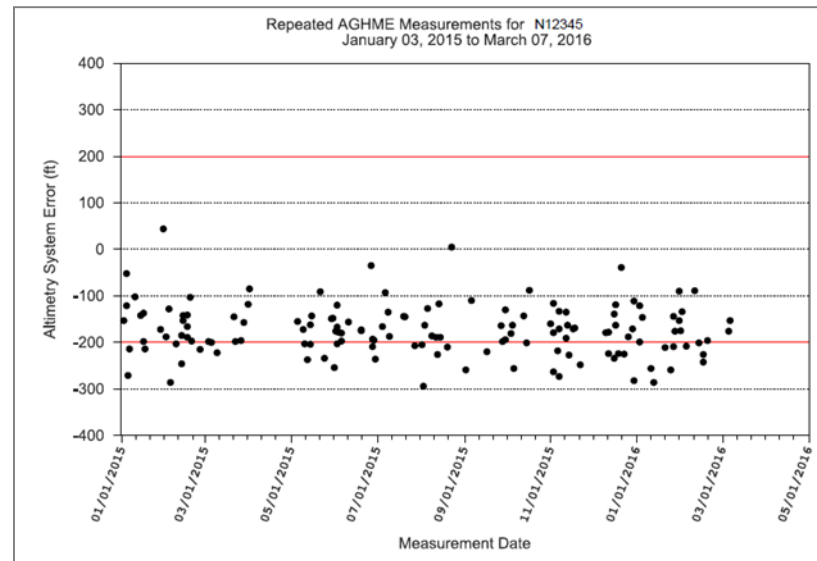


Approved ASE Result Processing

- Approved ASE results are loaded into the database for performance reviews
- Database Structured Query Language (SQL) scripts are executed to identify aberrant values for immediate evaluation
- Additional SQL scripts identify statistically aberrant performance evaluated over the current year of data which are individually evaluated
- Large ASE Reports (ASE-Rs) are issued when the QC team determines the ASE performance is near the non-compliant threshold
 - ✦ Ideally prior to non-compliance so maintenance and testing can be conducted without removing the aircraft from service

ASE-R Process

- NAARMO identifies aberrant performance for aircraft (ASE of 200 feet or greater).



- Aircraft placed on a watch list and identified as possible candidate for an ASE-R.
- NAARMO briefs Flight Standards on performance for the possible candidates for ASE-Rs.
- Team decides which are immediate candidates and presents findings to the Certificate Holding District Offices (CHDOs).

ASE-R Goals

- Educate all involved parties on the potential for large ASE existence (“invisible risk”) and the risks associated with large ASE.
- Deliver a compelling case detailing why large ASE should be taken seriously and what action is required
 - ✦ Ideally ASE is corrected before non-compliance
- Improve aircraft performance
- Improve system safety

RVSM APPROVALS DATABASE



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RVSM Approval Requirement

- In order to ensure that the overall safety objectives of the air traffic services (ATS) system can be met, all aircraft operating in airspace where RVSM is applied are required to hold an approval, issued by the State of the Operator or State of Registry as appropriate, indicating that they meet all the technical and operational requirements for such operations.
- The specific aircraft type or types that the operator intends to use will need to be approved by the State of Registry of the aircraft or of the aircraft operator.
- RVSM approval issued for one region will always be valid for RVSM operations in another region provided specific restrictions have not been imposed on the operator by the State of the Operator or State of Registry.
- This requirement, and the responsibility of States with regard to the issuance of these approvals, are specified in 7.2.4 b) of Annex 6, Parts I and II.



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Reference: ICAO Doc 9937, Forward; ICAO Doc 9574, paragraphs 3.3.1, 3.3.2



RVSM Approval Elements

- RVSM approval will encompass the following elements:
 - a) Airworthiness approval (including continued airworthiness). The aircraft will be approved as meeting the requirements of the appropriate State airworthiness document derived from the height-keeping capability requirements as defined by the RVSM MASPS [Minimum Aviation System Performance Standard]. Furthermore, the aircraft altimetry and height-keeping equipment must be maintained in accordance with approved procedures and servicing schedules; and
 - b) Operational approval. As defined by ICAO regional air navigation agreements, it may be necessary for an operator to hold a separate RVSM-specific operational approval in addition to an RVSM airworthiness approval to operate in RVSM airspace.



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Reference: ICAO Doc 9574, paragraph 3.3.1



RVSM Approvals Data Collection

- An RMA serves as a focal point for the collection and collation of RVSM approvals for aircraft operating under its jurisdiction.
- To avoid duplication by States in registering approvals with RMAs, all States are associated with a particular RMA for the processing of RVSM approvals.
- Links with other RMAs are established in order to determine the RVSM status of aircraft it has monitored, or intends to monitor, so that a valid assessment of the technical height-keeping risk can be made.



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Reference: ICAO Doc 9937, paragraphs 2.2.1, 2.2.3



RVSM Approvals Database Requirements

- To properly maintain and track RVSM approval information, some basic aircraft identification information is required (e.g. manufacturer, type, serial number, etc.) as well as details specific to an aircraft's RVSM approval status.
- There are frequent changes to aircraft registration data. Changes to registration and/or operating status data are required to properly maintain an accurate list of the current population as well as to correctly identify height measurements.
- An accurate and up-to-date list of contacts is essential for an RMA to do business.
 - ✦ State Airworthiness Officials
 - ✦ Operators
 - ✦ Manufacturers



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Reference: ICAO Doc 9937, Appendix D, paragraphs 1,2 and 3



Minimum Aviation System Performance Standards (MASPS) Database

- The FAA Separation Standards Branch maintains the Minimum Aviation System Performance Standards (MASPS) database to support the Reduced Vertical Separation Minimum (RVSM) program, and the North American Approvals Registry and Monitoring Organization (NAARMO), which is the ICAO endorsed Regional Monitoring Agency (RMA) for North America.
- NAARMO performs analysis of RVSM aircraft and operator approvals: evaluates operations specification approvals, letters of authorization, validity of registration information, and height monitoring compliance.
- Currently the total population of US registered aircraft is >300,000 of which >20,000 are involved in the RVSM program.
- NAARMO shares approvals and monitoring information with the other Regional monitoring agencies (RMAs). Data is also uploaded to the 'US RVSM Approvals and AGHME Monitoring Status Results' website on a monthly basis, from this output FAA Inspectors and aircraft operators are able to view the RVSM approval and height monitoring status of an aircraft.

Summary

- This presentation serves an introduction to more detailed discussions to follow during the workshop
 - ✦ Data elements
 - ✦ Monitoring Methods
 - ✦ Meteorological Analysis
 - ✦ ASE Processing
 - ✦ RVSM Approvals
- Several breakout sessions are planned for working sessions in specific areas of analysis

Questions?