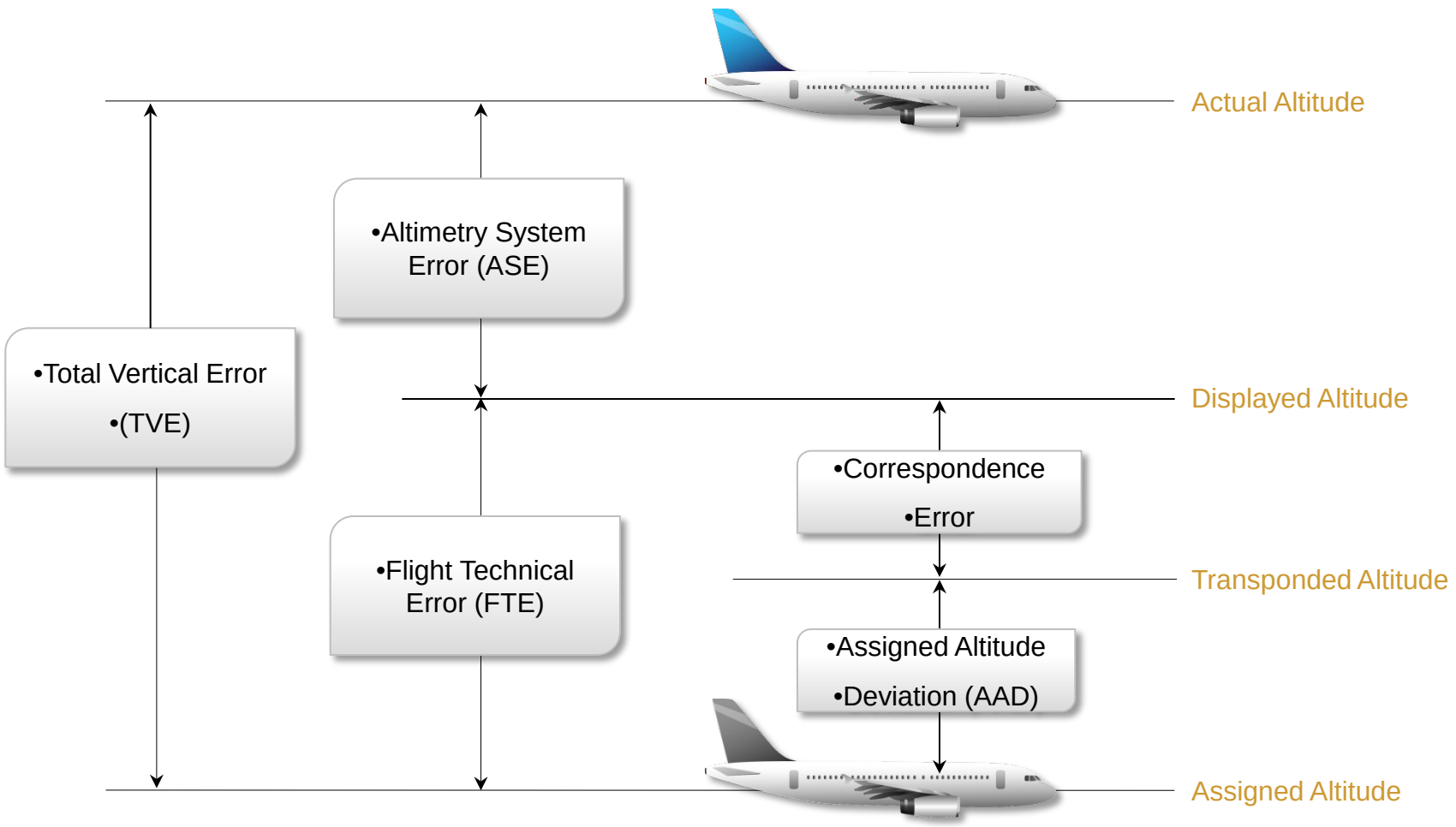

NextGEN
Altimetry System Error (ASE) Data Collection and Performance Monitoring
FAA ANG-E61
FAA
Federal Aviation Administration

Topics for Discussion

- Data Elements and Issues
- Monitoring Methods
- AGHME Quality Control
- ASE Watch List
- Metrological Analysis
- RVSM Approval Database

DATA ELEMENTS AND ISSUES

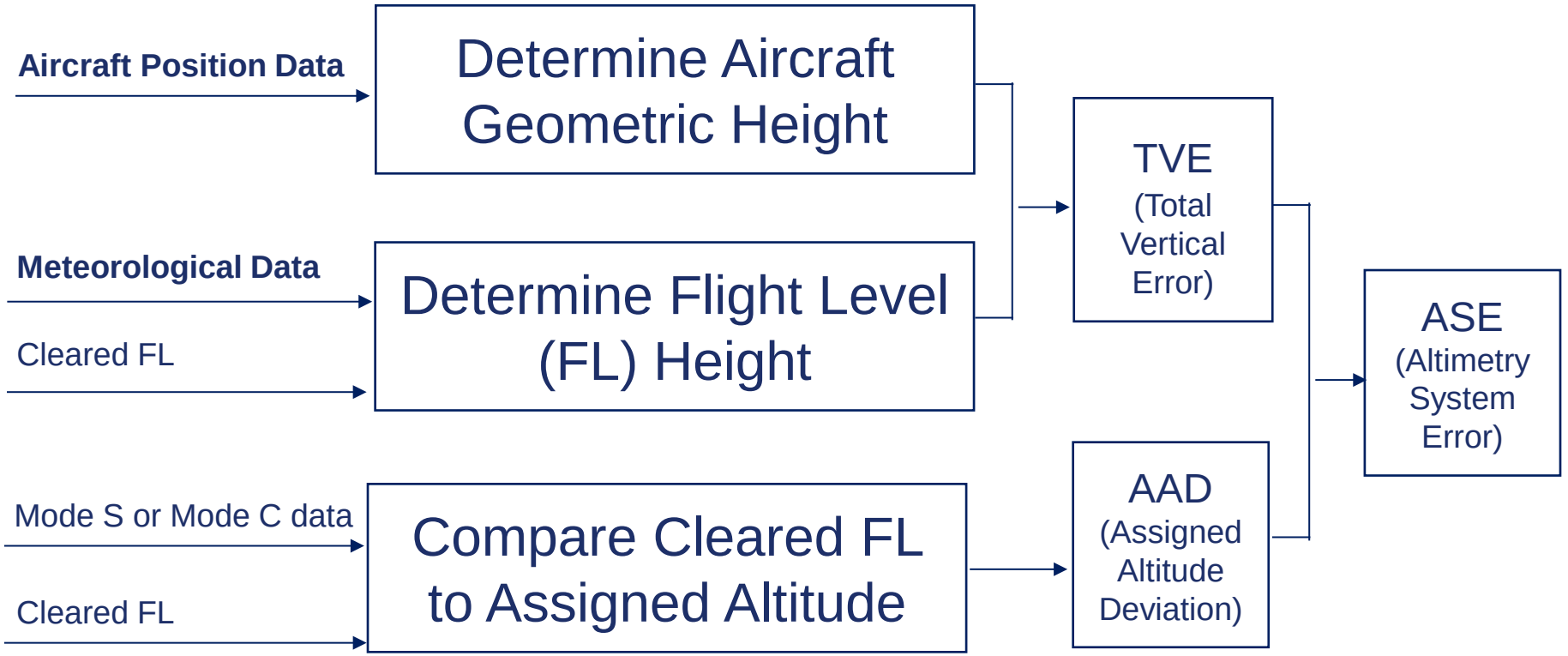
Total Vertical Error (TVE)



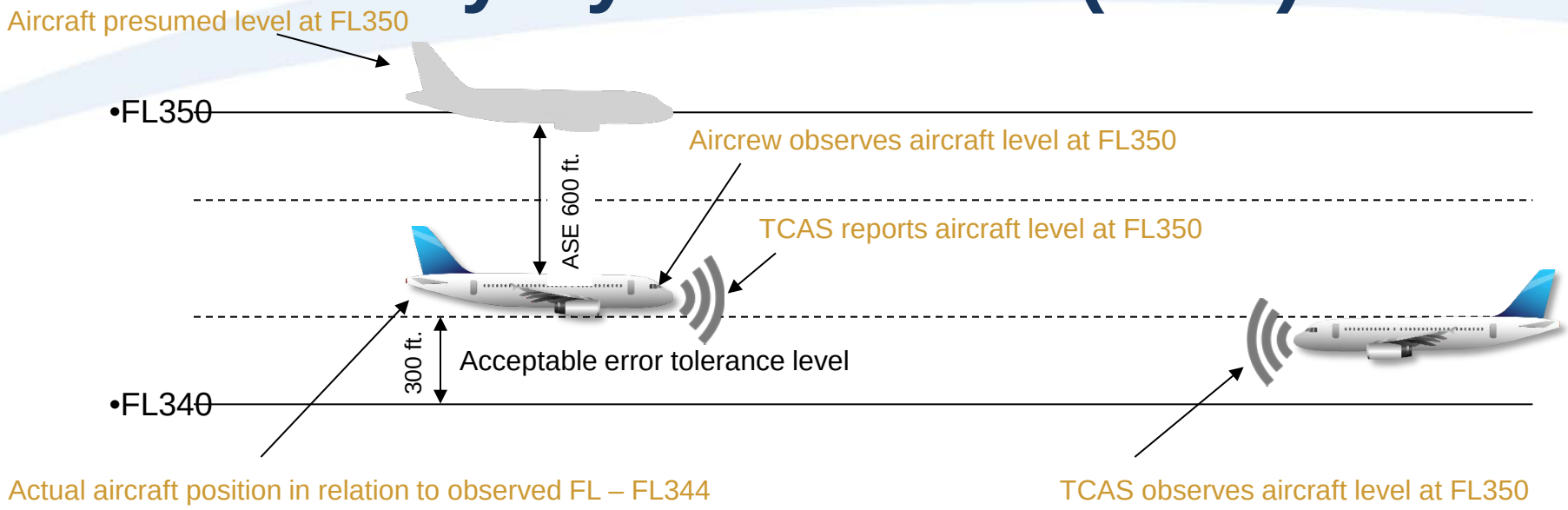
Elements of Total Vertical Error

- 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

Altimetry System Error Calculation Process



Altimetry System Error (ASE) Risk



✓ 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

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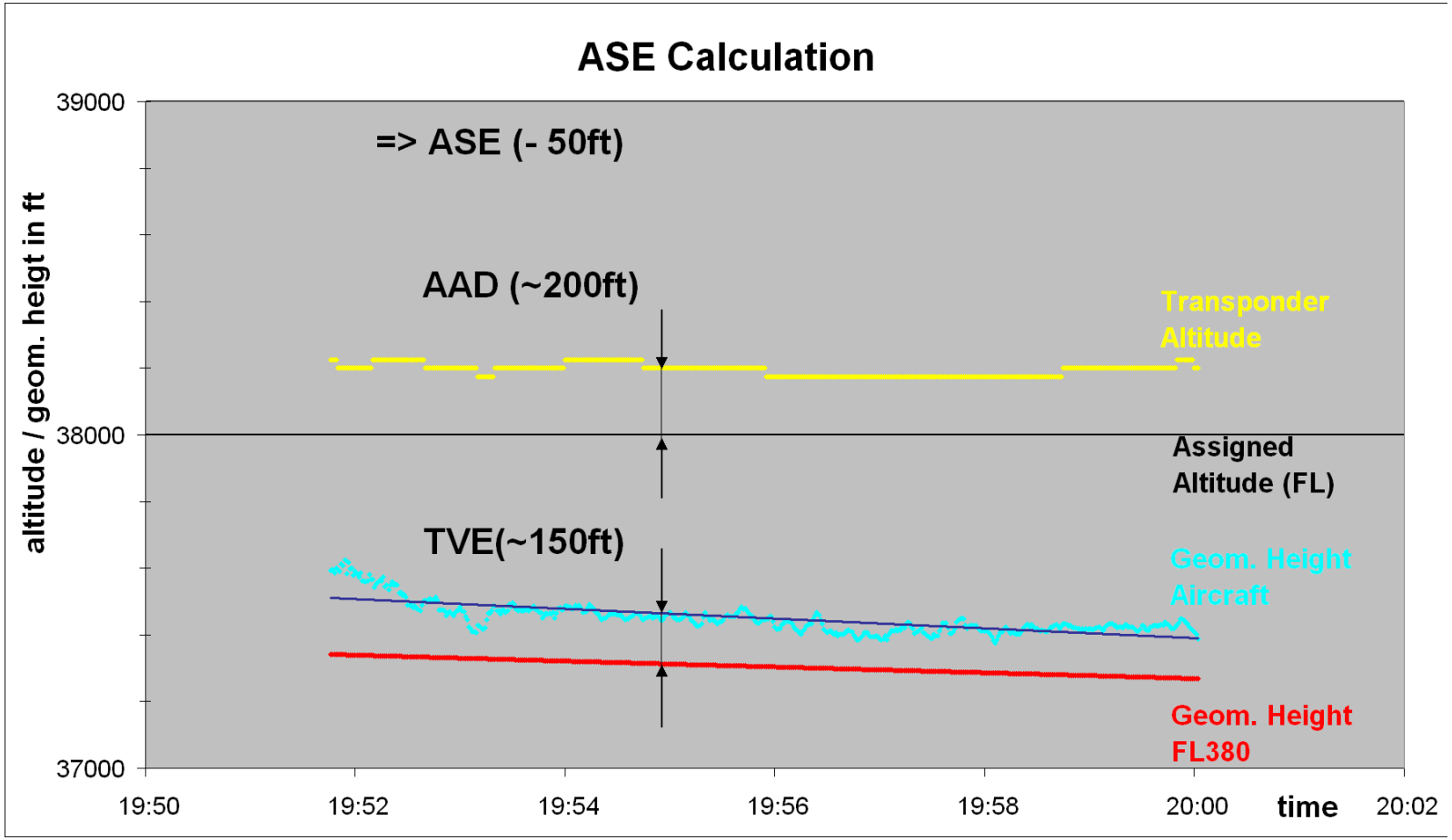
Baseline of the Height Monitoring



MONITORING METHODS

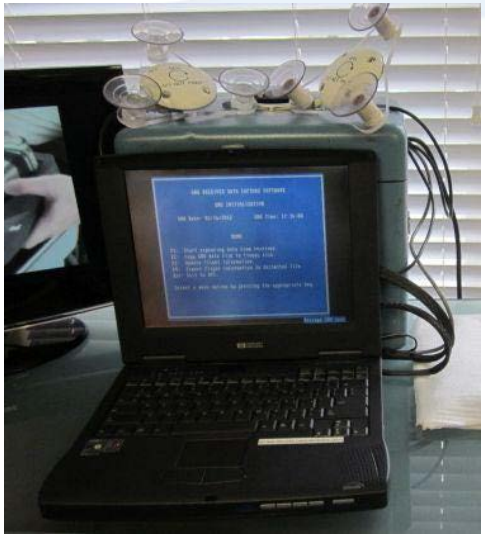
Monitoring Methods

- Height keeping performance of an aircraft is measured by equipment independent of the aircraft's altimetry system.
- Aircraft must be airborne and operating at an RVSM altitude for the performance to be measured.
- Height keeping performance monitoring requires operators to use specialized monitoring systems.

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

Enhanced^2 GPS Monitoring Unit
E^{2}GMU - 2013

Total Number of GMU Monitorings as of 30 August 2016 = 19,260

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GMU Monitoring Flights
Totals by Month/Weekly Average

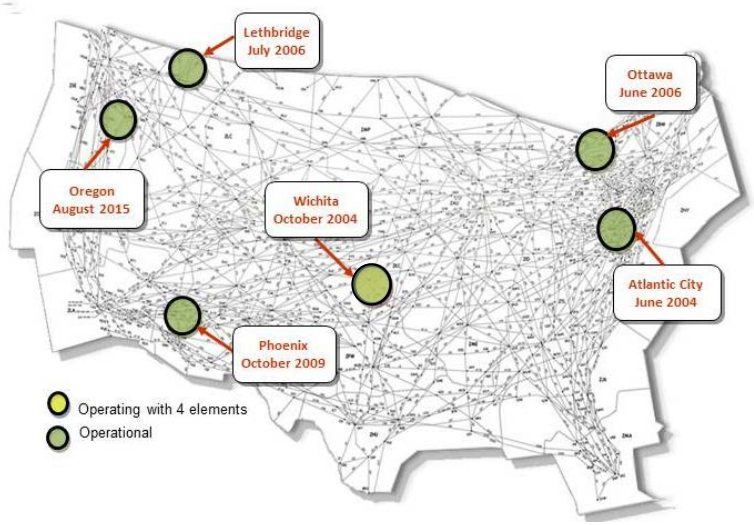
Year	Total Of SeqNo	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC		Weekly Avg.
1995	4								1			1	2		
1996	221		1	2	4	4	16	29	18	10	20	40	77		4
1997	1040	68	110	128	74	79	72	72	81	113	120	60	63		20
1998	636	67	55	53	53	85	58	55	49	47	46	32	36		12
1999	447	21	37	37	25	42	33	31	35	34	30	73	49		9
2000	795	65	63	83	86	81	89	51	50	56	50	60	61		15
2001	562	38	31	28	29	48	63	32	43	54	60	58	78		11
2002	953	83	64	57	96	81	82	92	77	83	74	87	77		18
2003	1278	89	85	92	99	108	101	89	99	114	130	134	138		25
2004	3028	122	175	210	225	218	275	212	318	297	259	299	418		58
2005	2116	303	217	231	199	218	226	209	120	116	106	85	86		41
2006	821	82	71	79	64	78	61	56	62	70	60	74	64		16
2007	613	48	48	51	39	43	73	33	44	59	59	61	55		12
2008	653	47	41	59	53	48	51	65	73	43	59	58	56		13
2009	614	48	63	57	46	52	75	42	41	51	48	55	36		12
2010	573	37	42	63	47	39	61	50	50	41	44	54	45		11
2011	594	35	44	50	32	58	54	45	48	53	51	74	50		11
2012	1195	65	61	65	41	68	65	66	122	111	197	249	85		23
2013	934	77	85	120	101	77	64	61	84	66	62	65	72		18
2014	850	83	62	67	51	84	64	55	58	86	86	80	74		16
2015	900	42	70	84	80	95	90	65	69	77	95	58	75		17
2016	433	56	81	78	29	51	48	39	51						14

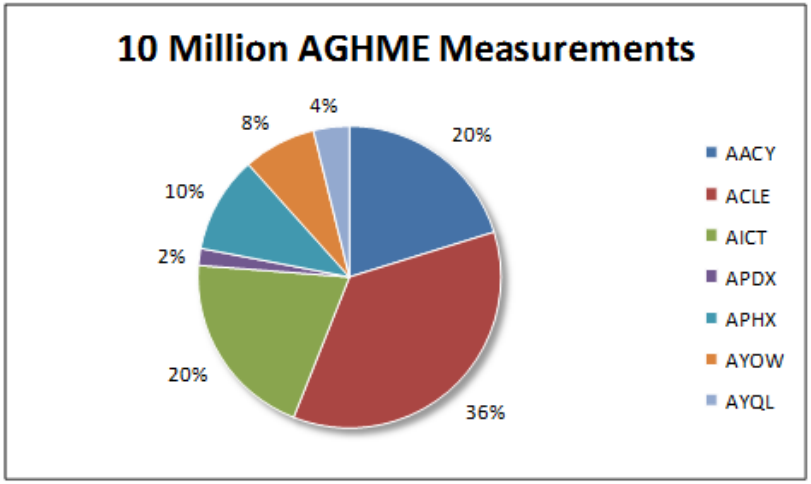
Ground Based Monitoring Systems: Aircraft Geometric Height Measurement Element (AGHME)

- 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.

AGHME Locations & Percentages (2005- March 2016)

AGHME Locations in US and Canada





Equipment

STATENAME	Count
United States	8655915
Canada	923638
United Kingdom	95657
Germany	52261
Unknown	44729
France	42696
Mexico	29361
Kingdom of the Netherlands	28147
Ireland	18102
China (PRC)	11825
United Arab Emirates	10121
Republic of Korea	8874
Switzerland	7146
Japan	6759
India	6549
Luxembourg	5928
Qatar	5821

Number of ASE Records seen by AGHMEs by State since 2005

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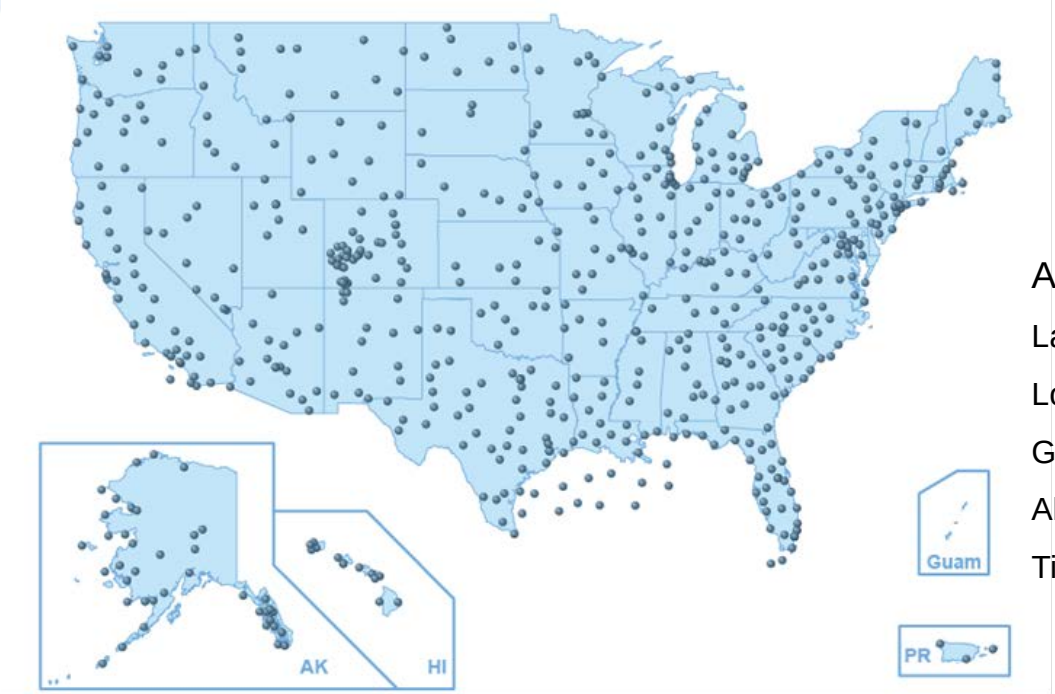
Ground Based Monitoring Systems …continued
ADS-B Height Monitoring System



ADS-B Coverage Map
as of October 2015

ADS-B Fields

Latitude	Mode S Address
Longitude	Ground Station
Geometric Height	Flight Identification
Altitude	Navigation Accuracy Category
Time	

2012 – February 2016 Data Sample for only DO-260 B Airframes

Designated RMA	State	Total 1090ES DO-260B Airframes
NAARMO	Canada	89
	Mexico	49
	United States	2,456

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AGHME QUALITY CONTROL

AGHME Quality Control (QC) Process

- Two primary sources of ASE measurement error must be evaluated before the result can be considered valid
  - Aircraft true position and the modeled value of the pressure surface
- Accepted quality parameters are built into the ASE processing software to flag likely erroneous ASE values
- Experienced analysts review ASE results periodically to identify remaining large ASE values
- QC has an established watch list of large measurement
  - Subsequent large measures of a singe aircraft on repeated assessments are reported to the operators via the FAA inspector
  - Comparison of multiple aircraft at the same time or by area are used to remove the likely faulted measurement

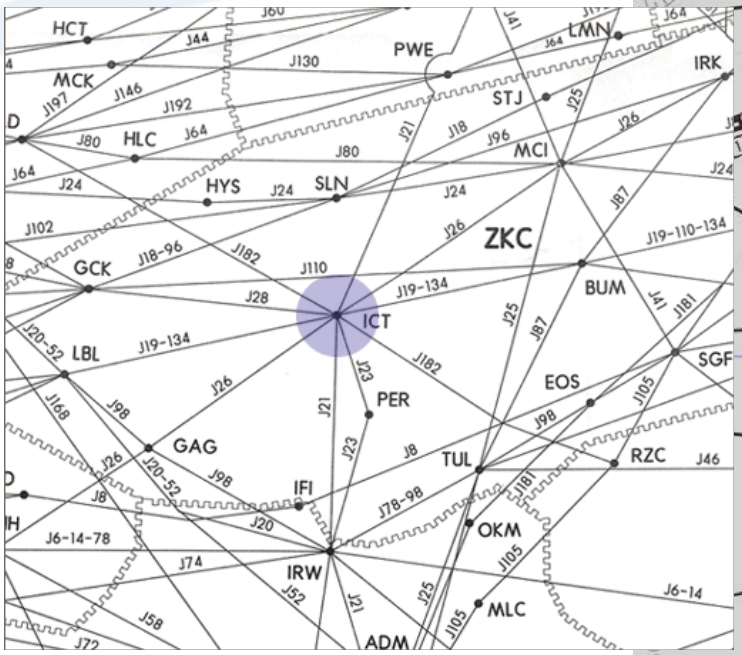
Altimetry System Error (ASE) Process

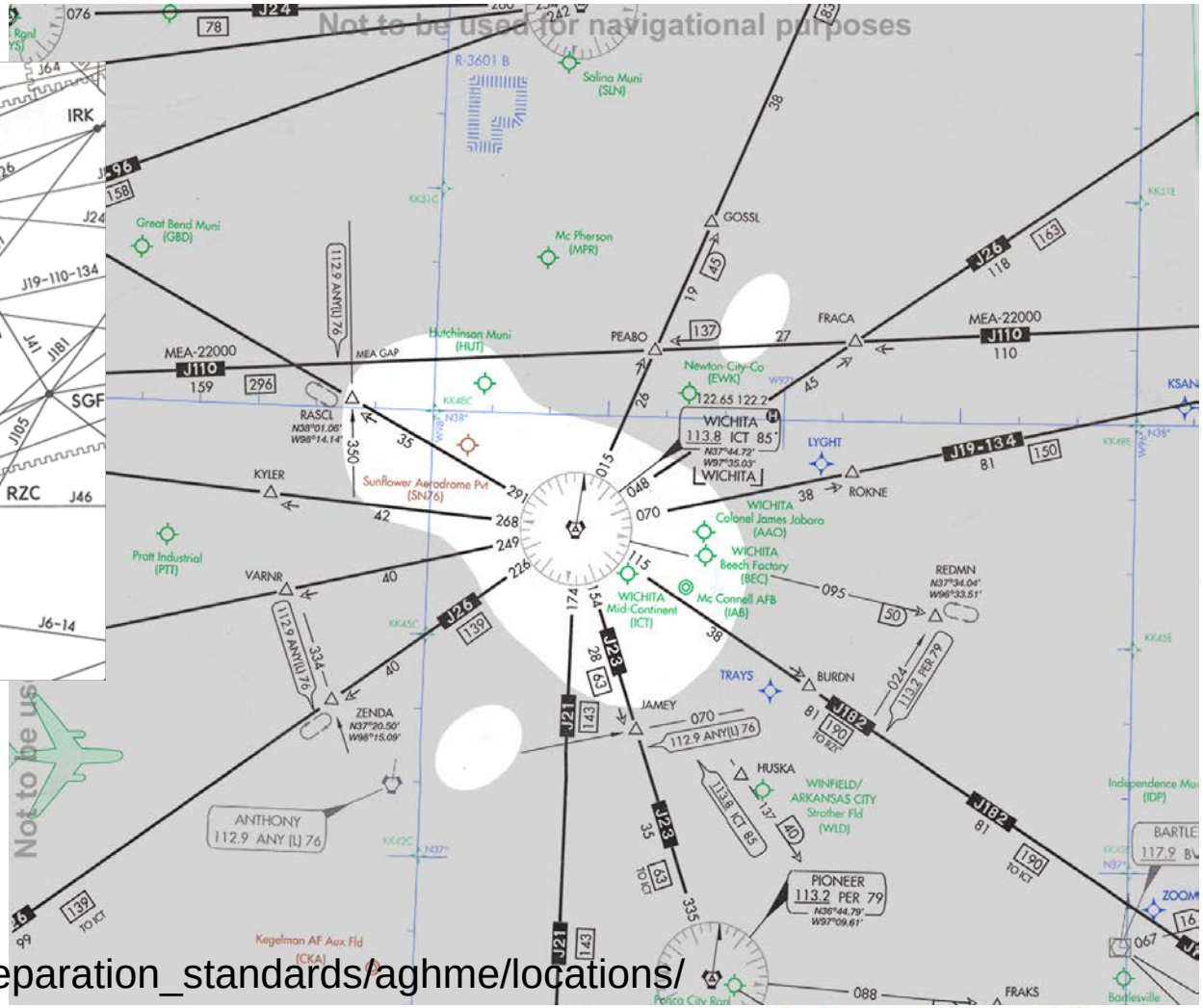
- ASE is determined by comparing the identified true height of the aircraft and the true height of the barometric pressure surface associated with the altimetry measurement
  - The true altitude is currently measured by the Aircraft Geometric Height Element multilateration systems operated by ANG-E61
  - Aircraft that require ASE monitoring that do not fly over one of the AGHME sites can utilize a GPS measurement unit to collect aircraft position as an input to the ASE process
  - ADS-B provides a source of aircraft position data for use in ASE calculations
    - The quantity of data that will be provided by ADS-B will provide unprecedented ability to observe ASE

Flight Quality - Geometry

- For ASE to be properly measured by the AHGME, the geometry of the flight path should be aligned with the identified performance area of the system
- This assures that multiple elements of the AGHME station will measure the aircraft range for the altitude calculation

AGMHE Coverage Area: Wichita, Kansas





https://www.faa.gov/air_traffic/separation_standards/aghme/locations/

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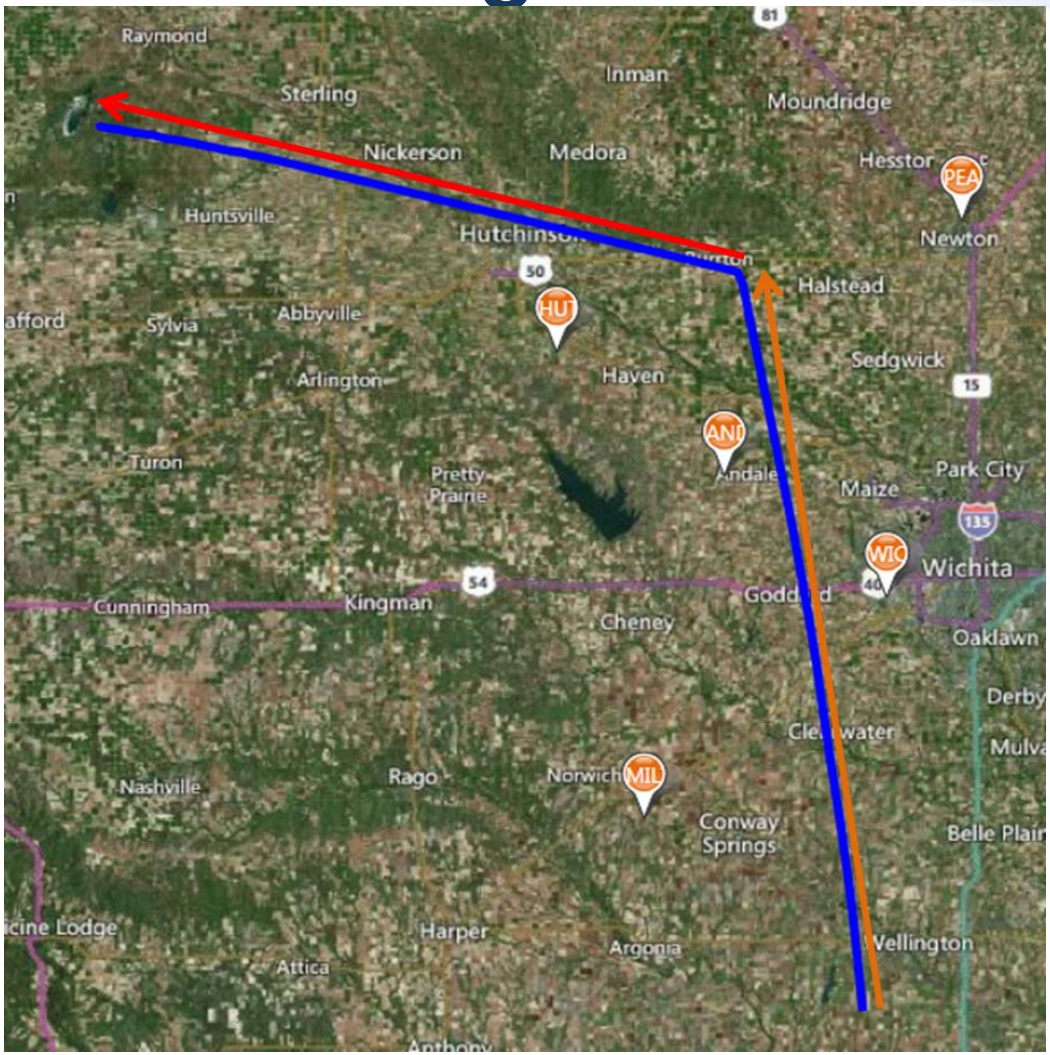
Recent AHGME Flight

ASE -101
SD 10
Segment 1

ASE 224
SD 123
Segment 2



Which ASE is correct?

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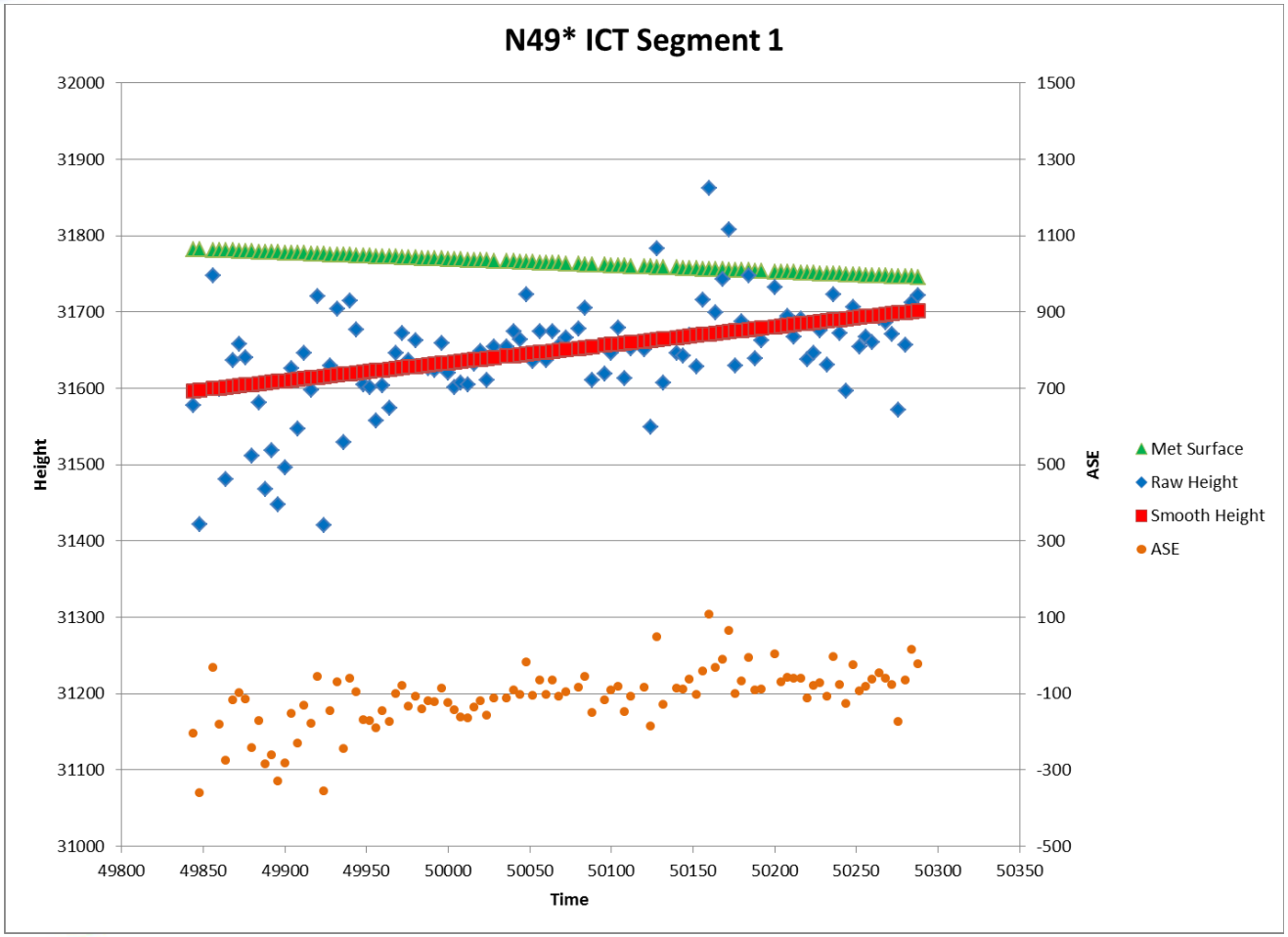
Flight Segment 1 MARS Plot (Met/ASE Raw & Smoothed)



- Well-sampled flight
- 444 Second Duration
- Moderate MET/Aircraft surface agreement

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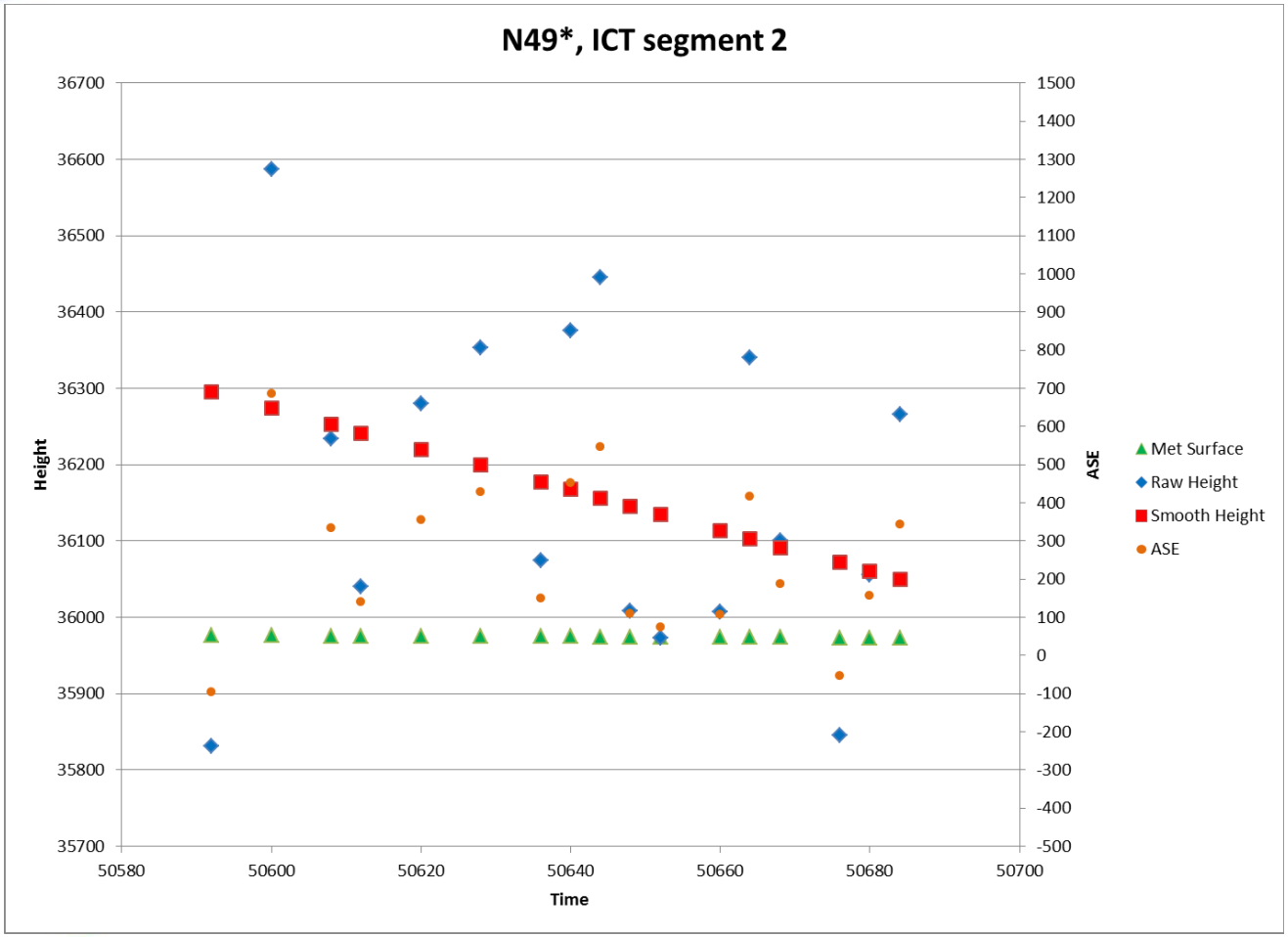
Flight Segment 2 MARS Plot



Poorly-sampled flight path

72 Second Duration

Poor MET/Aircraft surface agreement

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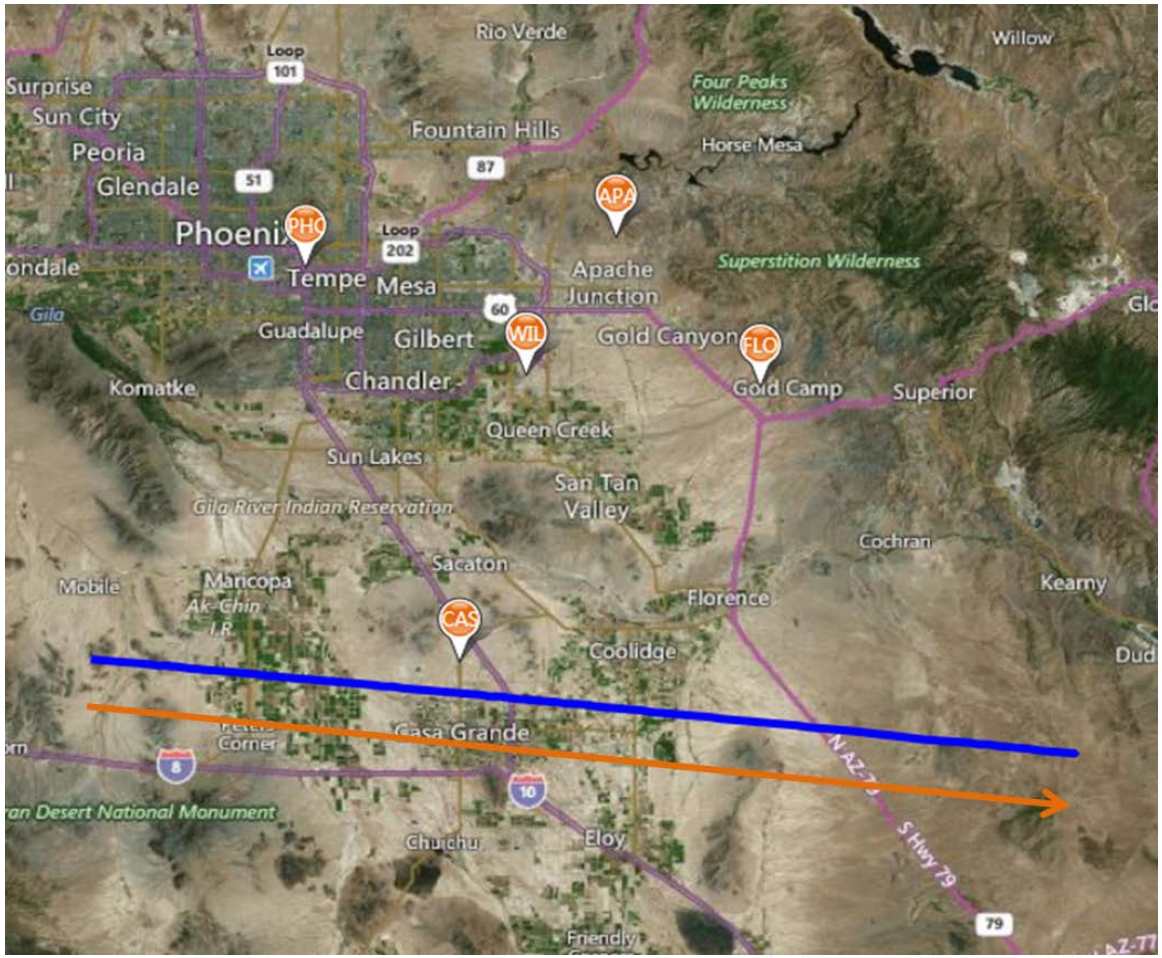
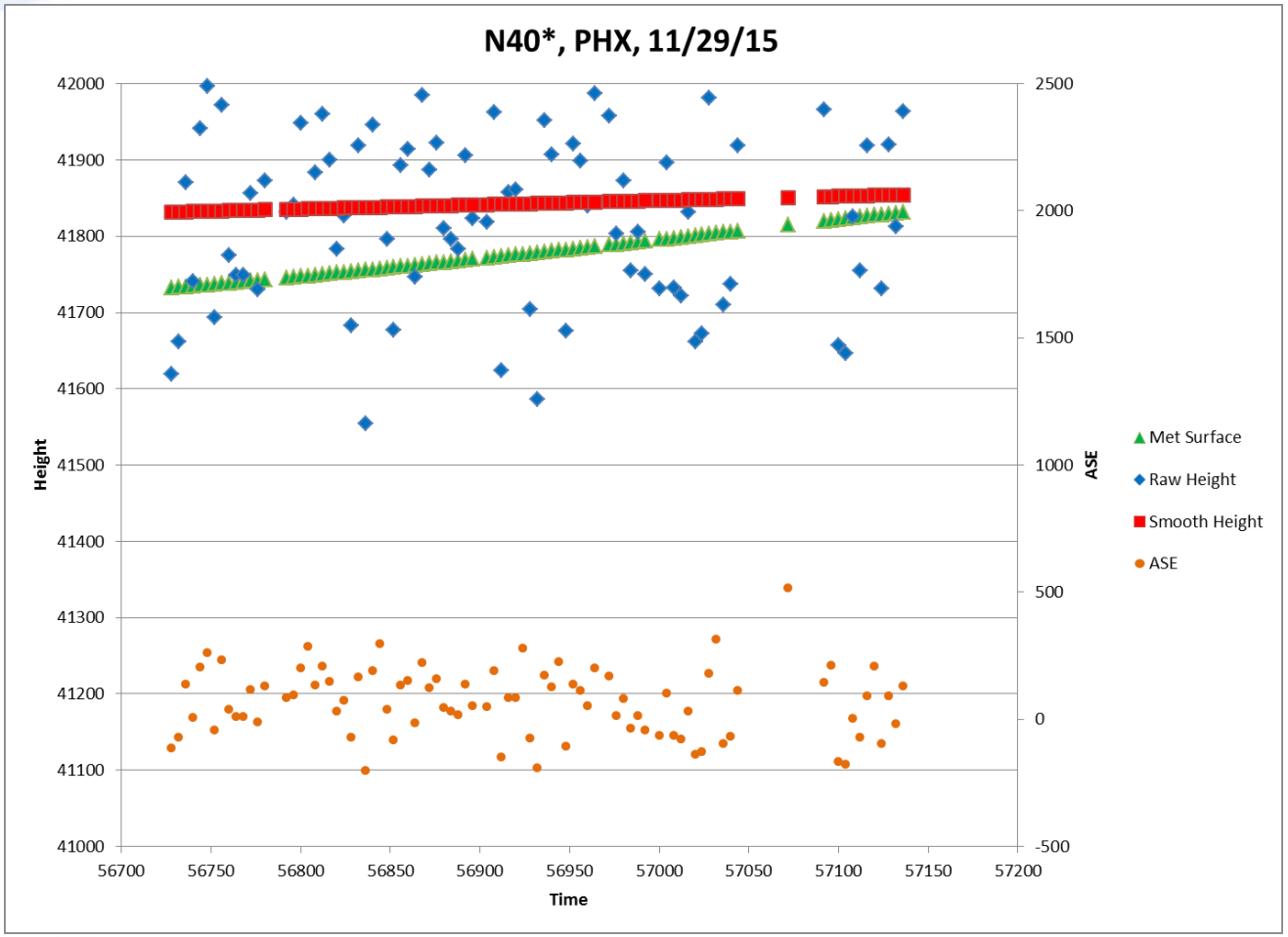
Pressure Surface Alignment Sample Case with ADS-B

PHX
ASE 70
SD 42



Smoothed Height and MET Alignment



Well-sampled flight

308 Second Duration

Moderate MET/Aircraft surface agreement

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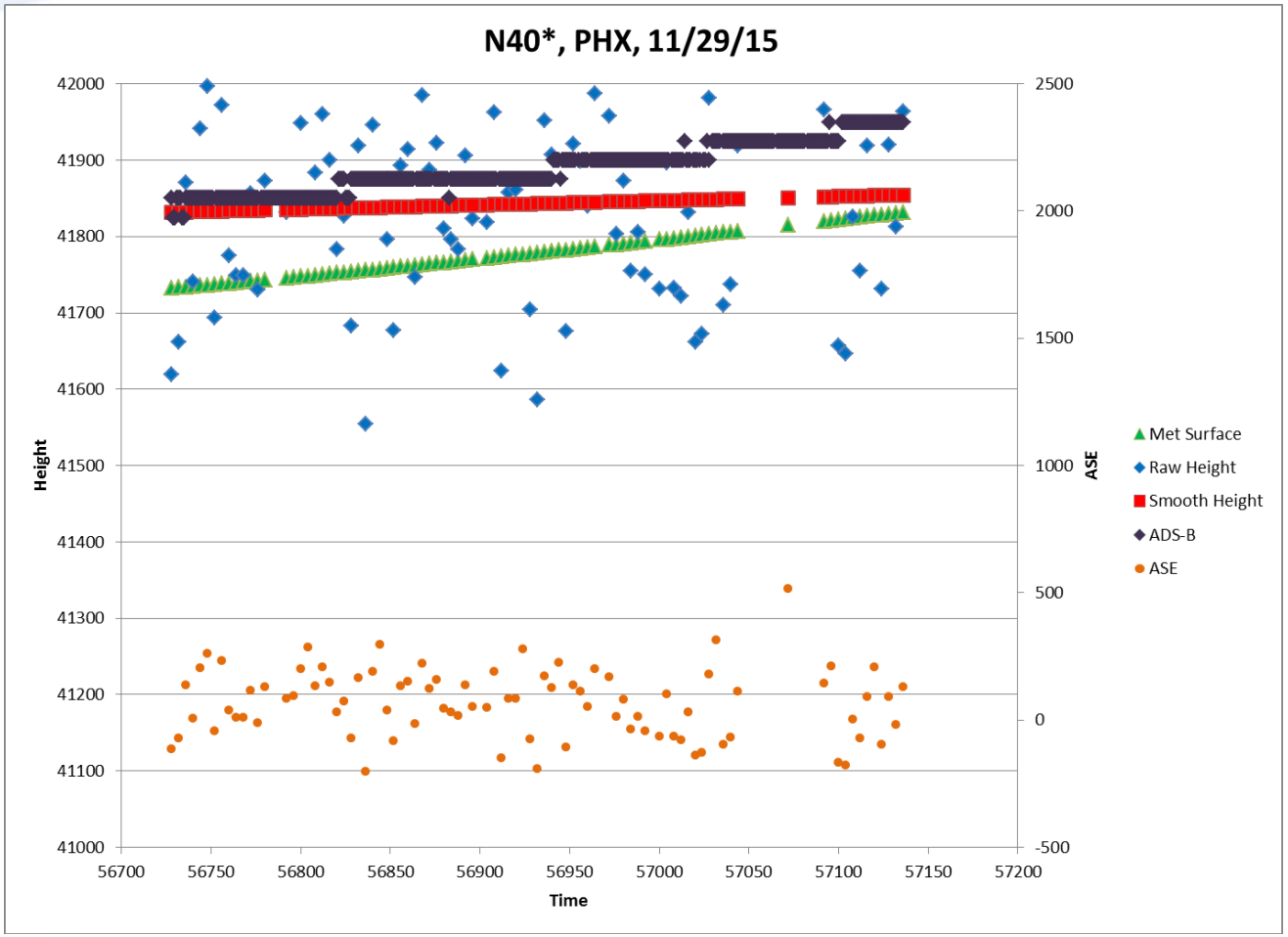
Smoothed Height and MET Alignment – ADS-B (MAARS)



Continuous ADS-B data aligned with AGHME data

Improved MET/Aircraft surface dynamic agreement

ADS-B ASE
Mean 114ft (70)
SD 11ft (42)

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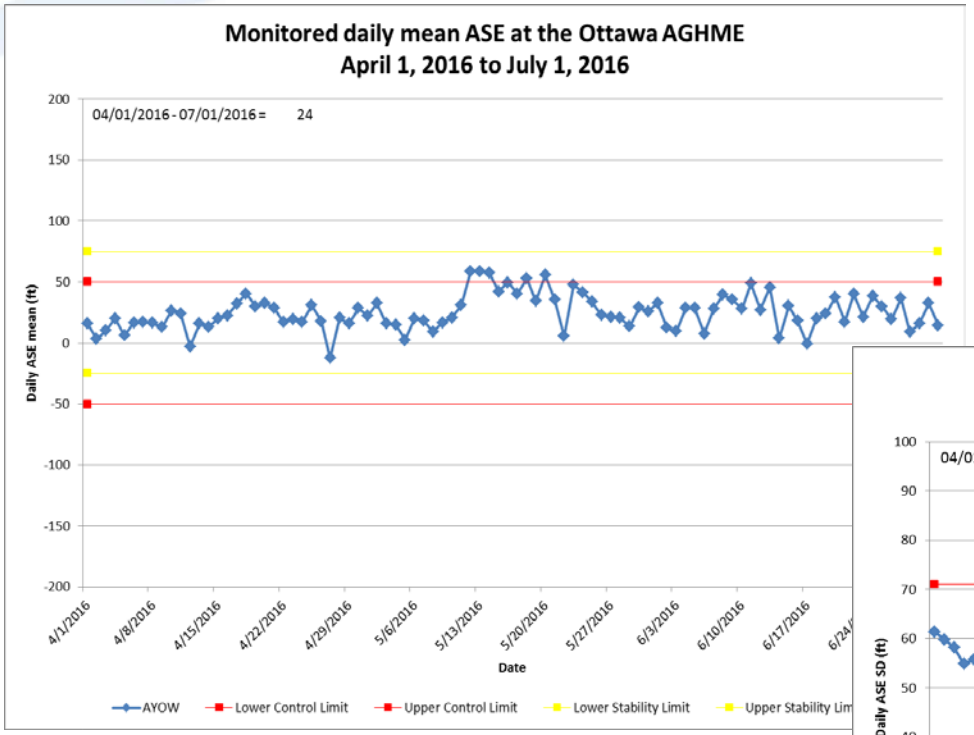
Flight Quality - Dynamics

- ASE is only currently processed when the aircraft is flying straight and level
  - Maneuvers create uneven air flow over the aircraft
- A minimum flight segment of 3 minutes is required
  - Multiple measurements during that time are averaged
  - AGHME data is “geometrically limited” – the flight duration will only be as long as the flight distance over the system
  - ADS-B coverage provides continuous data allowing for multiple independent ASE samples to be collected and compared.

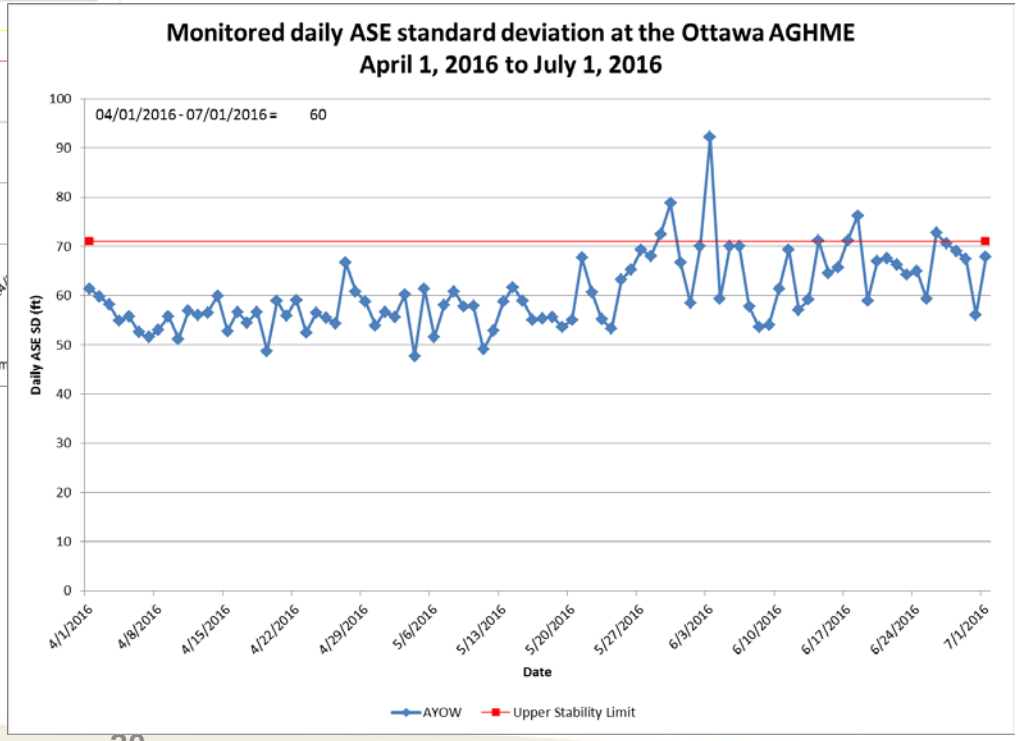
Meteorological Data Quality

- Pressure Surface variation that to no match the expected model results will translate into erroneous ASE assessment
- Data evaluation based on the expected values of each sites performance can be used to detect bad MET fit
- A large standard deviation of the ensemble of site ASE measurement is used as a trigger for daily evaluation
  - The QC team can elect fail all or some of the data

Daily Statistics from Ottawa



An Elevated daily mean or standard deviation triggers QC data evaluation



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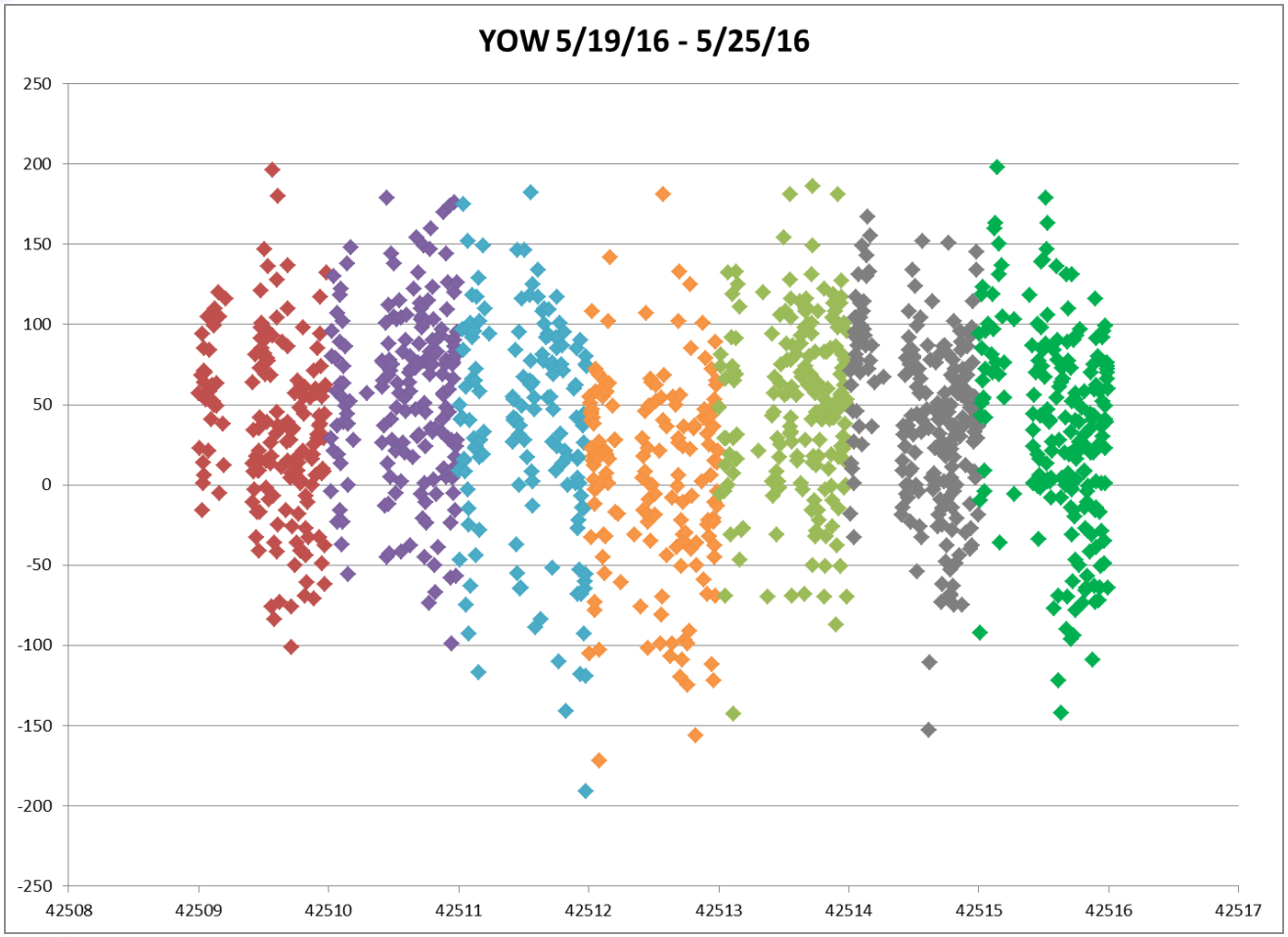
Daily Comparison of Ensemble ASE



May 22, shown in orange, had a significantly lower ensemble bias that the prior and following days

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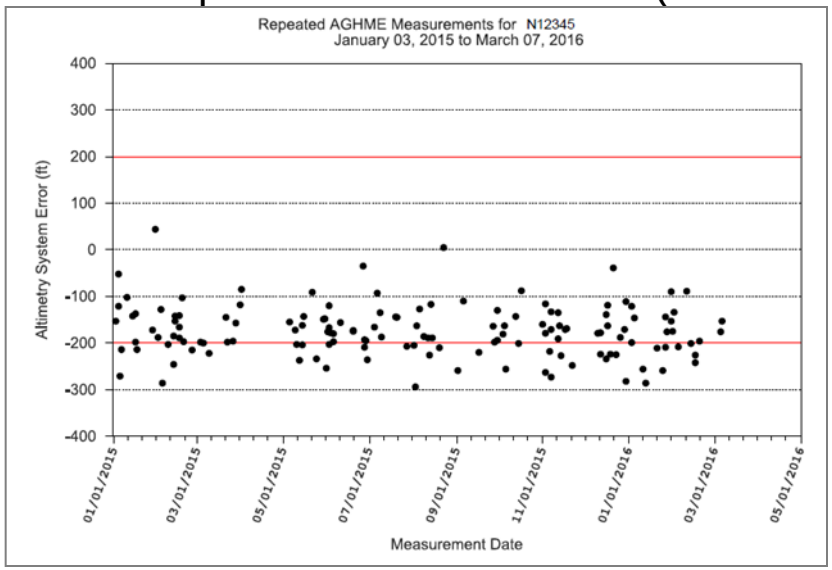
WATCH LIST AND LARGE ASE REPORTS

Background

- Analysis of ongoing height performance monitoring results has revealed that ASE can vary.
  - Individual aircraft or an entire aircraft group
- The need to establish an ASE independent monitoring program with a reporting process was identified.
- For North American registered aircraft, ANG-E61 coordinates reporting of unsatisfactory RVSM aircraft performance with FAA Flight Standards Headquarters and FAA Flight Standards Safety Inspectors responsible for safety oversight of RVSM Operators.
- The ASE-R assists the Federal Aviation Administration (FAA) and operators in identifying RVSM aircraft which exhibit unsatisfactory height keeping performance.

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).

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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 action should be taken immediately
- Improve aircraft performance
- Improve system safety

ASE-R

Altimetry System Error Report (ASE-R)

Date: August 26, 2016
Control Number: ASE-R ###

To: Operator Name
Operator Address

Prepared by: North American Approvals Registry and Monitoring Organization
Federal Aviation Administration
Atlantic City International Airport
Atlantic City, NJ 08405

Subject Aircraft Registration: N12345

Safe operation within Reduced Vertical Separation Minimum (RVSM) airspace requires stringent limits on the measurement of true aircraft altitudes during normal operations. Aircraft use a barometric altimeter to determine altitude and follow common pressure/flight levels. Differences between the altitude indicated by the altimeter display and the actual pressure altitude corresponding to the undisturbed ambient pressure, known as altimetry system error (ASE), occur. These errors are not apparent during flight operations. Therefore the altimeter displays to the aircrew and air traffic control a level that includes ASE. As such, the presentation to the pilot, ATC, and airborne collision avoidance systems is often different than the actual height of the aircraft. To be compliant with international standards, the ASE of an aircraft must be minimized and be no greater than 245 ft. Aircraft with observations of ASE greater than 245ft in magnitude are candidates for removal of RVSM credentials and subject to immediate action.

Continued safe RVSM operations require a high level of accuracy from altimetry systems; therefore ongoing system performance monitoring as well as individual aircraft performance monitoring are necessary to ensure that safety goals and requirements are met. In order to support monitoring needs in accordance with international standards, requirements and recommended practices [1] [2] [3], the Federal Aviation Administration deployed six ground-based height monitoring units, also known as Aircraft Geometric Height Measurement Element (AGHME) systems, in the North American Region. These monitoring systems were strategically placed in high traffic flow areas and continuously record aircraft performance data.

The subject aircraft has been monitored by one or more AGHME systems and was found to exhibit large ASE values in magnitude greater than 200 feet. The William J. Hughes FAA Technical Center Quality Control Team in conjunction with the North American Approvals Registry and Monitoring Organization (NAARMO), tasked to provide Reduced Vertical Separation Minimum (RVSM) monitoring services to other Regional Monitoring Agencies (RMA) and State Authorities, cite ASE data collected in Tables 1-2 and Figures 1-4 as reason for safety concern.

Section I: Subject Aircraft and ASE Measurement Overview

Table 1. Aircraft Profile

Operator:	Operator Name
Registration Number/Mode S Address:	N12345 / A12345
Aircraft Type/Series/Serial Number:	B737 / 7H4 / 12345
RVSM Ops Date, Expiration Date:	01/01/2016, None
Equipment ID Field:	L
Large Recent Measurement(s):	a) AACY 08/03/2015 ASE = -294 feet b) ACLE 02/05/2015 ASE = -286 feet c) ACLE 01/13/2016 ASE = -286 feet
GMS#, Date GMS Monitored (MM/DD/YY):	None
European Monitored:	N/A

[1] ICAO Doc 9574: "Manual on Implementation of a 300 m (1 000 ft) Vertical Separation Minimum Between FL 290 and FL 410 Inclusive"
[2] Annex 11 to the Convention on International Civil Aviation
[3] 14 CFR Part 91 Appendix G

Section II: Data Analysis and Performance Summary

The following table and figures provide a summary of aircraft ASE performance and comparative data.

Table 2. Recent ASE Performance of Subject Aircraft

AGHME Identification	Date of Measurement	ASE	Flight Level
APHX	03/07/2016	-153	320
AICT	03/06/2016	-176	390
APHX	02/20/2016	-196	410
ACLE	02/17/2016	-226	400
ACLE	02/17/2016	-242	390
ACLE	02/14/2016	-201	410
APHX	02/11/2016	-89	340
AICT	02/05/2016	-208	390
AICT	02/02/2016	-134	380
AICT	02/01/2016	-175	370
AICT	01/31/2016	-153	380
ACLE	01/31/2016	-90	410
APHX	01/28/2016	-176	410
AICT	01/27/2016	-144	360
ACLE	01/27/2016	-209	410

Figure 1 provides an overview of this aircraft's ASE performance at each AGHME element during a recent period.

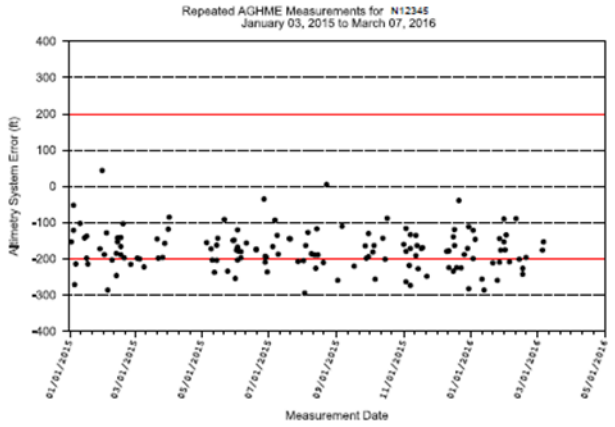

Figure 1. Aircraft Altimetry System Error History

ASE-R

Figure 2 provides a depiction of daily ASE observations from a single AGHME site on the day of the maximum observation of the subject aircraft.

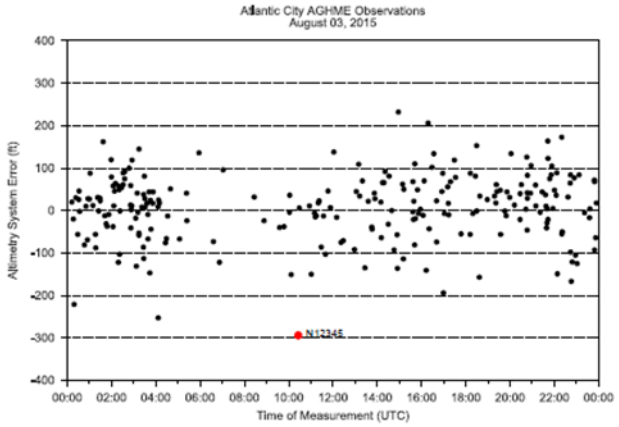

Figure 2. Atlantic City AGHME Observations Illustrating an Extreme Observation of the Subject Aircraft

Figure 3 is a comparison of the average ASE performance of aircraft of a similar type.

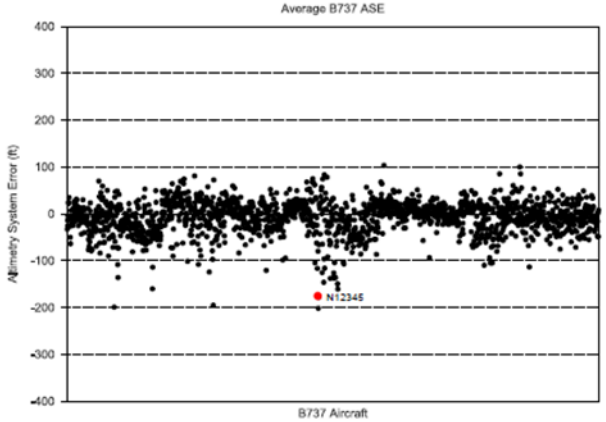

Figure 3. Average B737 ASE for the Past Year

Figure 4 illustrates the probability (99.7%) that the ASE of a B737 aircraft will take a value within the expected range for this aircraft type.

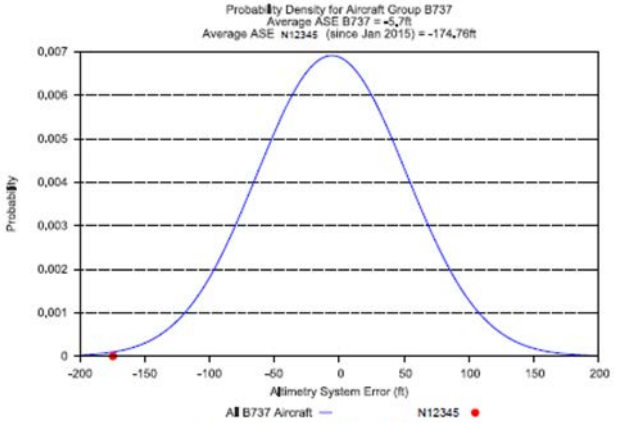

Figure 4. Probability Density, B737 Aircraft

Section III: Continuing Maintenance Issues

During routine calibration, the aircraft systems are maintained on the ground while at rest, so the dynamic nature of ASE is not able to be seen. Aircraft altimetry systems also utilize parts that:

- wear over time (such as the pitot-static probe and portions of internal plumbing); and/or
- are subject to damage (such as skin flexing/deformation during operations); and/or
- are affected by modification of airframes (such as the application of paint, decals and branding marks or mounting of accessories or repairs such as boiler plating in the vicinity of the static pressure ports).

Aircraft need to operate within RVSM limitations as published in the Aircraft Flight Manual (AFM).
All these activities are capable of producing significant error in true height. Other factors seen in normal operations of high-speed flight such as aerodynamic loading and exposure to ranges of temperature, moisture and contaminants, are also capable of producing significant variation in the sensed pressure.

Section IV: Action Required

Because of this larger than normal or non-compliant value, it will be necessary to determine and remedy the cause or causes of non-compliant performance by the altimetry system and then repeat the monitoring process in order to demonstrate compliant performance. Prior to repeating the monitoring flight, the operator should ensure up-to-date compliance with the approved maintenance program, carefully inspect the aircraft altimetry system critical areas and review all relevant factors in order to determine any possible explanations for the observed ASE value.

Please complete the attached resolution form and submit to NAARMO@faa.gov or fax to 609 485-5078 within 15 days or less of receipt of this report. Please note the aircraft's altimetry system error must be corrected within thirty (30) days of FAA acceptance of the resolution plan.

ASE-R Resolution

- Upon completion of the corrective actions the aircraft RVSM height keeping gets revaluated.
- A notice of resolution gets sent by the core team to the CHDO.
  - This includes both positive and negative outcomes.
- Upon satisfactory review by the core team and the CHDO a decision is made to close the action on the ASE-R and the aircraft is removed from the watch list.
- If the maintenance leads to unsatisfactory performance, work is coordinated between all parties to continue to remedy the problems.

ASE-R Resolution

Altimetry System Error (ASE) Report

Resolution Sufficient

Date: September 30, 2016
Control Number: ASE-R XX-8

To: Inspector Name
CHDO address

Subject Aircraft Registration: N12345

Prepared By: North American Approvals Registry and Monitoring Organization
Federal Aviation Administration
Atlantic City International Airport
Atlantic City, NJ 08405

On August 26, 2016 the North American Approvals Registry and Monitoring Organization reported large Altimetry System Error for subject aircraft registration N12345 (report control number ASE-R XX). In the report data were presented demonstrating large ASE performance. A recommendation for maintenance review was advised to bring the ASE performance within RVSM compliant levels.

Upon further data inspection of the subject aircraft from recent AGHME monitoring, the subject aircraft is now within RVSM compliant levels.

The following plot (Figure 1) indicates repeat ASE measurements before and after notification of large ASE performance.

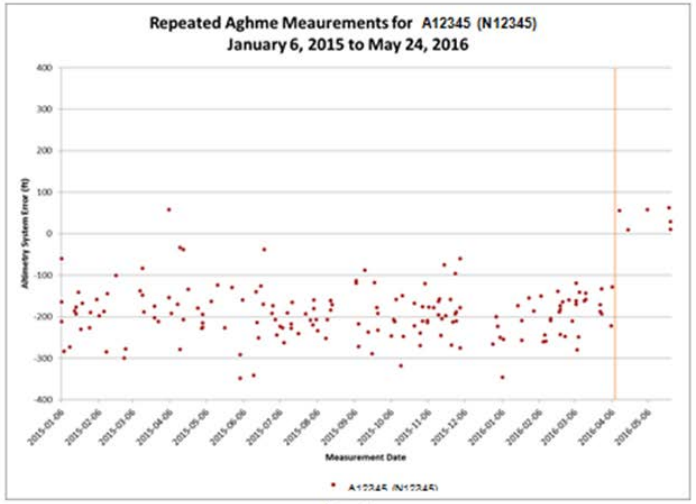

Figure 1

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Conclusion

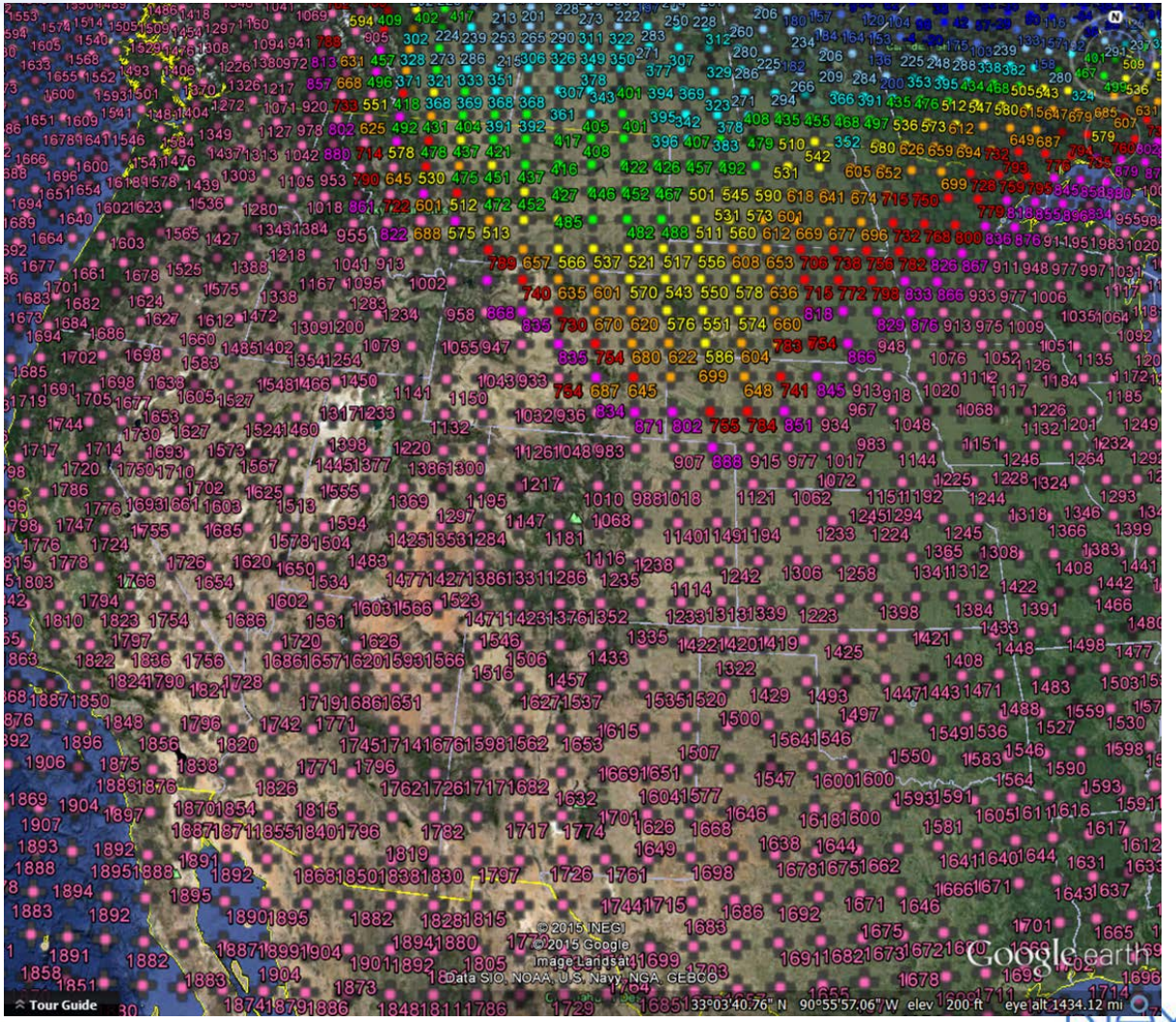
- This is an evolving process.
- Not all cases are the same.
- Working with Flight Standards has vastly helped in receiving the feedback needed to improve safety.
- While sometimes cost can be an issue, operators have been extremely helpful throughout the ASE-R process.

METROLOGICAL ANALYSIS

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
- Mismatch of the modeled pressure surface and the actual pressure surface causes error in the ASE estimate

Correction Between Pressure and True Altitude FL300



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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

Flight Level Height Estimation (Flight Levels Are Pressure Surfaces)

- Aircraft fly and maintain altitudes by measuring meteorological pressure levels defined by the Standard Atmosphere
- For each RVSM flight level [290 – 410] there is a corresponding mb level (pressure surface) that is defined by the Standard Atmosphere
  - For example, when an aircraft is assigned FL290 (29,000 feet), the aircraft avionics / pitot static system will try to measure a mb level of 314.94911 as defined by the Standard Atmosphere

Pressure Surface

let $p1_i$ = standard atmosphere mb levels
= {400, 300, 250, 200, 150, 100}, i= 1,…,6
$h1_i$ = standard atmosphere geopotential heights (feet) at mb levels $p1_i$
= {23574.2, 30065.4, 33999.1, 38661.3, 44646.8, 53082.8}
$h2_j$ = standard atmosphere geopotential flight levels heights
= {29000, 310000,…,45000}, j=1,…,9
$p2_j$ = standard atmosphere mb levels at $h2_j$ flight level heights
= {314.84911, 287.44595, 262.00689, 238.42236, 216.62475,
196.77083, 178.73656, 162.35514, 147.47510}

← Standard Atmosphere
Pressure and Height

$h3_i$ = WAFS geopotential heights at mb levels $p1_i$ (input variable)
t_i = WAFS temperatures at mb levels $p1_i$ (input variable)
$\dot{t}$ = mean WAFS temperatures between mb levels (estimated variable)
$\dot{t}1$ = mean WAFS temperatures between mb levels and flight level (estimated variable)
$\tilde{h}$ = geopotential flight level height (estimated variable)

← WAFS Input
Height and Temperature

let d = $(t_{i+1} - t_i) / (h1_{i+1} - h1_i)$
$\dot{t}1 = t_i + (d/2)(h2_j - h1_i)$
r = $\ln(p1_i/p2_j) / \ln(p1_i/p1_{i+1})$
d1 = $(\dot{t}1 / \dot{t})$ r
then
$\tilde{h} = h3_i + d1 (h3_{i+1} - h3_i)$

← Equations
Flight Level Height Estimation

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RVSM APPROVALS DATABASE

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.

RVSM Approvals Database

- One of the functions of an RMA is to establish a database of aircraft approved by its State authority for operations in RVSM airspace in the region for which the RMA has responsibility.
- This information is necessary for two reasons:

  a) the RMA is responsible for verifying the approval status of all aircraft operating within its region; and

  b) height-keeping performance data must be correlated to an approved airframe.

Reference: ICAO Doc 9937, paragraph 2.1.1

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.

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.

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

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 319,946, of which 22,135 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.

US RVSM Approvals and AGHME Monitoring Status Results Sample from:

OpName	Type	Series	Ser No	Reg No	Full Approval	Last GMU Monitoring	Last Successful AGHME Monitoring	Other RMA Monitoring
JetDream Charter, LLC	CL60	2B16	5513	N604RB	TRUE	10/13/2002	4/13/2016	
Voyage Oil and Gas	CL60	2B16	5514	N880ET	TRUE	4/25/2002	8/22/2015	6/27/2016
LJ Associates, Inc.	CL60	2B16	5516	N118RH	TRUE	4/10/2002	2/22/2016	11/17/2015
SPX Corp.	CL60	2B16	5518	N85PX	TRUE	6/14/2004	2/23/2016	
AREA9	CL60	2B16	5519	N900UC	TRUE	7/18/2002	8/5/2016	3/13/2016
Ace Aviation Services Corp.	CL60	2B16	5524	N601GT	TRUE	9/18/2002	7/1/2016	1/14/2013
Highfields Capital Management LP	CL60	2B16	5531	N168NQ	TRUE	10/3/2002	2/21/2016	6/22/2015
AmTrust Underwriters , Inc.	CL60	2B16	5536	N25ZG	TRUE	6/19/2004	3/16/2016	6/23/2016
Mutual of Omaha Ins. Co.	CL60	2B16	5537	N437MC	TRUE	10/23/2002	11/1/2015	5/8/2014
Bombardier Flexjet	CL60	2B16	5543	N332FX	TRUE		6/15/2016	
JET SOLUTIONS, LLC	CL60	2B16	5543	N332FX	TRUE		6/15/2016	
Lincare Leasing, Inc.	CL60	2B16	5544	N814PS	TRUE		8/31/2010	1/29/2014
Jet Select, LLC	CL60	2B16	5545	N471RJ	TRUE	1/9/2003	6/26/2016	
Smith, Vicars & Company, LLC	CL60	2B16	5546	N100AC	TRUE	4/9/2003	6/20/2016	
Allied Energy, PLC	CL60	2B16	5547	N426PF	TRUE	1/16/2003	9/30/2015	8/16/2015
Celestial Airways, Ltd.	CL60	2B16	5548	N627AF	TRUE	1/21/2003	12/8/2015	
Sun Energy 1, LLC	CL60	2B16	5550	N75KH	TRUE	3/3/2003	7/28/2016	5/11/2016
Pepsico Aviation - Addison	CL60	2B16	5551	N501PC	TRUE	7/15/2003	6/28/2016	
Peter K. Jaffe	CL60	2B16	5554	N604KJ	TRUE	6/17/2003	4/10/2016	5/2/2013
Harbert Fund Advisors, Inc.	CL60	2B16	5555	N604HM	TRUE	10/17/2003	2/18/2016	
Pepsico, Inc. (White Plains)	CL60	2B16	5558	N508PC	TRUE	7/18/2003	4/25/2016	
MP Air, Inc.	CL60	2B16	5559	N902MP	TRUE	11/19/2003	5/1/2016	7/6/2014
Boston Scientific Corporation	CL60	2B16	5560	N604BS	TRUE	11/13/2003	5/1/2016	12/17/2015
Gama Aviation, LLC [135]	CL60	2B16	5562	N604VG	TRUE	3/13/2004	5/4/2016	4/25/2016
The Whitewind Company [91]	CL60	2B16	5563	N604BC	TRUE	11/20/2003	7/4/2016	5/21/2016
The Whitewind Co. [135]	CL60	2B16	5563	N604BC	TRUE	11/20/2003	7/4/2016	5/21/2016
Mustang Investment HoldingsLTD	CL60	2B16	5563	N604BC	TRUE	11/20/2003	7/4/2016	5/21/2016

RVSM Database Entry Tool