International Civil Aviation Organization

The Sixteenth Meeting of the Regional Airspace Safety Monitoring Advisory Group (RASMAG/16)

Bangkok, Thailand, 20 – 24 February 2012

Agenda Item 5: Airspace Safety Monitoring Activities/Requirements in the Asia/Pacific Region

REPORTING OF HEIGHT-KEEPING MONITORING RESULTS FROM ADS-B

(Presented by Australia)

SUMMARY

This paper provides examples of the types of reports the Australian Airspace Monitoring Agency (AAMA) generates to inform other RMAs, State regulators and operators of height-keeping monitoring results.

This paper relates to –

Strategic Objectives:
*A: **Safety** – Enhance global civil aviation safety*

Global Plan Initiatives:
GPI-2 Reduced vertical separation minima

1. INTRODUCTION

1.1. With the implementation of height-keeping monitoring using ADS-B technology, the AAMA has developed processes that enable it to automatically generate detailed reporting of a range of ASE values for airframes of specific operators.

2. REPORTING OF ADS-B HEIGHT-KEEPING MONITORING RESULTS

2.1. Attachments 1 and 2 to this paper provide de-identified examples of the reports that the AAMA can make available for other RMAs, State regulatory bodies and operators that detail ASE calculations and comparative data for specific airframes or fleet types.

2.2. Attachment 1 is an example of a report that provides a study of Altimetry System Error (ASE) for a particular operators airframes identified using ADS-B within Australian RVSM airspace. The report discusses airframes which are near the limit of acceptable ASE and general trends in the data. The appendices include explanations of various effects, the data analysis process and a summary of all results.

2.3. Attachment 2 is an example of an automatically generated report on ASE calculations based on Australian ADS-B data. The report is produced as an html file and has a number of interactive links embedded to assist the user. Information provided is specific to an operator's aircraft, and contains a Summary Table of all aircraft of that operator that have been monitored, daily ASE calculations for each aircraft with associated graph of the measurements, and graphs comparing the operator's measured aircraft by type against all other measurements of like type aircraft.

3. ACTIONS BY THE MEETING

3.1 The meeting note the availability of the types of reporting that the AAMA will be undertaking in relation to height-keeping monitoring activity using ADS-B. Reports of this type will be provided to RMAs to assist with identification of last successful monitoring of specific aircraft, or where the responsible RMA may need to take action where less than optimal ASE calculations are demonstrated.

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Attachment 1: Example of AAMA Altimetry System Error Analysis Using Australian RVSM Level, ADS-B data

Attachment 2: Example of ASE data and graphs for an individual operator provided by AAMA.

Attachment 1 to
RASMAG/16 IP/XX
20-24/02/2012

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AUSTRALIAN AIRSPACE MONITORING AGENCY (AAMA)

SAFETY & ASSURANCE GROUP

SAFETY SYSTEMS, RISK & ANALYSIS

Operational Analysis Unit

Altimetry System Error Analysis Using Australian RVSM Level, ADS-B data. XXXX Airways, January 2010 to June 2011

Executive Summary

ASE values were calculated for 61 airframes in the XXXX Airways fleet for the period January 2010 to June 2011.

It is recommended that the following aircraft altimetry systems be checked at the next convenient maintenance schedule.

name	mode_s	reg	type	operator	days	ASE (ft)
358	XXXXX	ABC	B744-10	XXX	8	-183
384	YYYYY	DEF	B744-10	XXX	2	-168
380	UUUUU	GHI	B744-10	XXX	5	-158
330	WWWW	JHK	B744-5	XXX	14	-146

Detailed analysis of all airframes, along with fleet comparisons is done in the attached HTML file.

ASE ANALYSIS USING AUSTRALIAN RVSM ADS-B DATA
XXXX AIRWAYS
JANUARY 2010 TO JUNE 2011

Prepared by
Australian Airspace Monitoring Agency (AAMA) – ***December 2011***
(An ICAO APANPIRG approved Regional Monitoring Agency)

1. Introduction

1.1 This report provides a study of Altimetry System Error (ASE) for XXXX Airways (XXX) airframes identified using ADS-B within Australian RVSM airspace. The data spans the period 1/1/2010 – 30/6/2011 and identifies 61 airframes. The initial analysis was done using an automatic data processing system. Further analysis of individual airframes is also carried out where necessary.

1.2 This report first discusses airframes which are near the limit of acceptable ASE and general trends in the data. The appendix includes explanations of various effects and the data analysis process. A second appendix summarises all results.

2. Airframes with high ASE

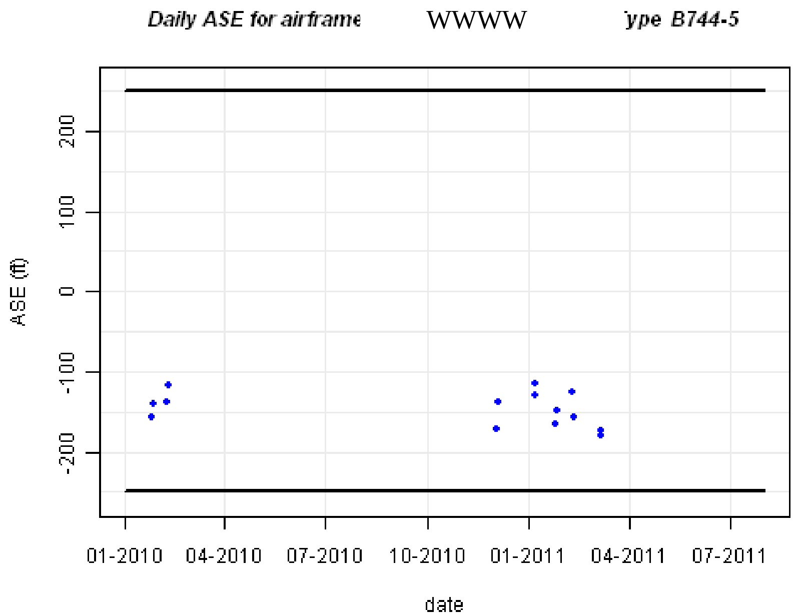
2.1 The airframes in Table 2.1 have high ASE levels. These are detailed individually after the table.

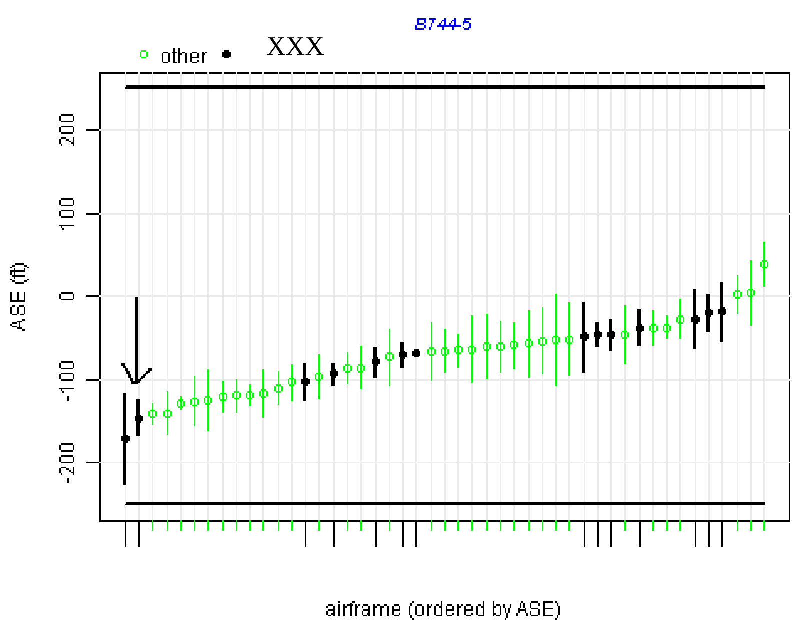
name	mode_s	reg	type	operator	days	ASE (ft)
358	XXXXX	ABC	B744-10	XXX	8	-183
384	YYYYY	DEF	B744-10	XXX	2	-168
380	UUUUU	GHI	B744-10	XXX	5	-158
330	WWWW	JHK	B744-5	XXX	14	-146

Table 2.1: *The internal name is Airservices internal reference number used only in the ASE process. The mode-s, registration and airframe type are given as well as the operator code. "no. days" is the number of days that samples were obtained. The final ASE value (ft) is given along with the date that the airframe was last monitored.*

2.1 Airframe=WWWW, JHK, B744-5, ASE = -146

2.1.1 This airframe has limited data dating back to February 2010. There is the possibility that this ASE value may have degraded since February 2011. The value of -146 is at the lower extremes of all the B744-5 airframes in our data. Below is a plot of the ASE value in feet over the data period. The lower plot indicates the ASE value for airframe against the other (47) B744-5 airframes identified in the sample. The black lines on this lower plot are the XXX B744-5 airframes, with the green lines the B744-5 airframes from other operators. The arrow indicates airframe WWWW.





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Appendix A – General notes and information.

A.1 This section gives some background to interpretation of ASE results.

A.2 The ASE values are calculated using aircraft flight level and aircraft geometric height sourced from Australian ADS-B data. This requires a complex mathematical analysis of meteorological data in order to estimate the flight level which corresponds to a given GPS-derived altitude. A comparison of an airframe's altimetry-derived flight level and this GPS-derived flight level gives the ASE.

A.3 The main sources of error in estimating ASE are

1. quantization of flight level and GPS geometric height data (+/- 25 ft); and
2. modelling interpolation of finite meteorological data.

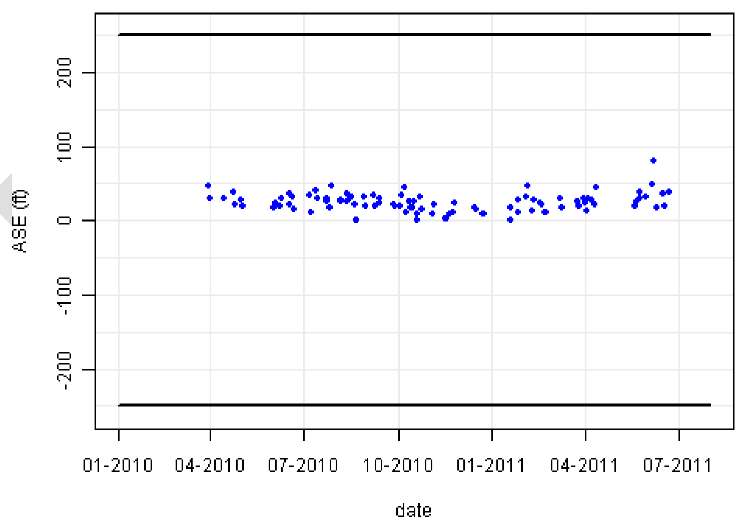
A.4 Meteorological errors would be the same regardless of which type of ASE estimation system is used (ADS-B, HMU, AGHME). The ADS-B derived ASE data has the advantage of a very large quantity of data covering many periods of flight. This nullifies the effect of quantization errors and reduces the overall ASE error.

A.4 Meteorological error is unavoidable and due to the finite collection of meteorological data, in both space and time (every 12 hours).

A.5 These sources of error are generally random, meaning that taking averages of data over a day, and then averages of these daily results over longer time periods, enables an accurate measure of ASE. A typical ASE calculation will involve 100 days of data and 100,000 data points, hence providing an accurate ASE value.

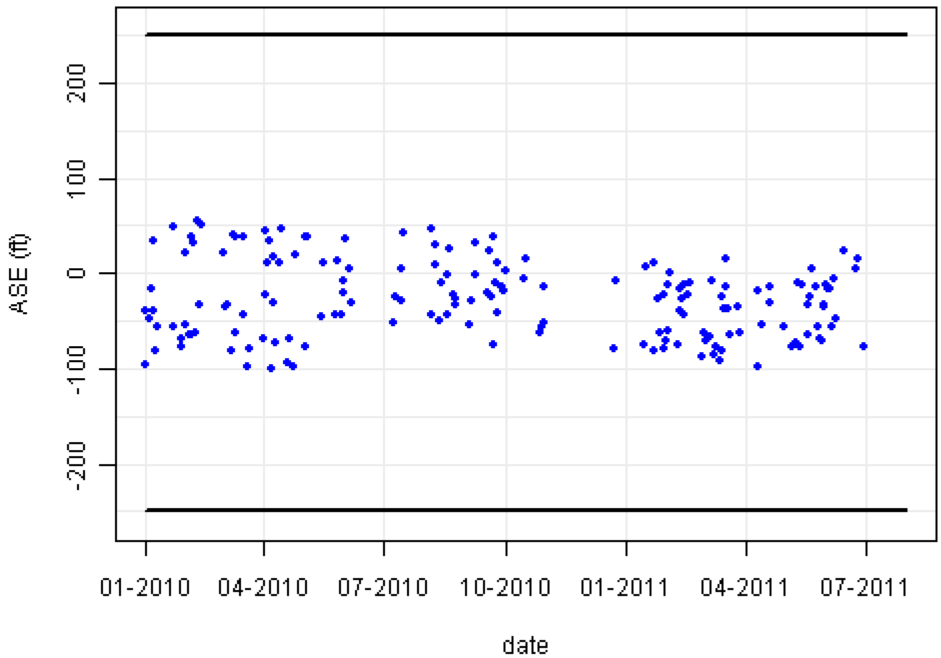
A.6 Each data point shown in the graphs is an average result over a single day.

A.7 A typical result for a well-performing airframe is shown below:

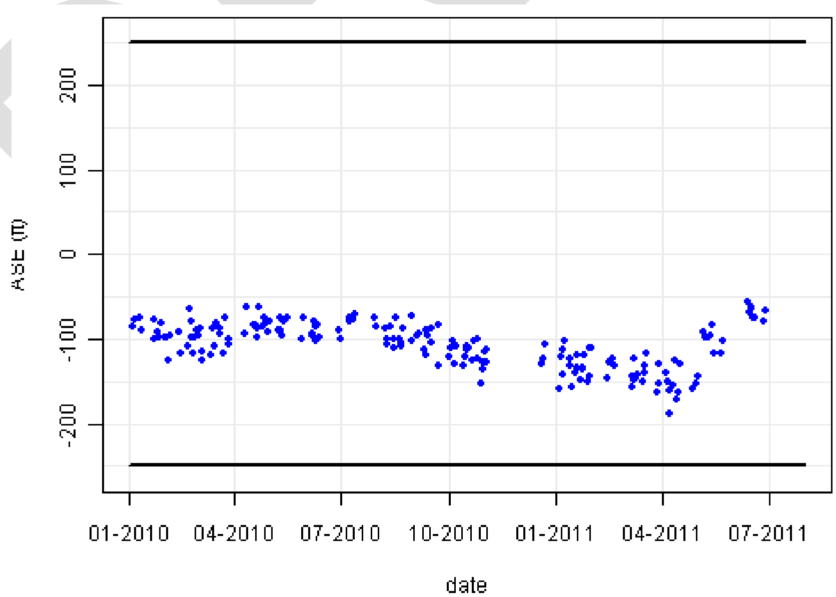


A.8 Note that the scatter in the above airframe is of the order of +/- 25 feet and that the ASE value (8 ft) is a good average figure to represent the data.

A.9 Some airframes give larger scatters in the data. This may be due to the airframe having split pitot systems; that is the pilot/co-pilot altimetry systems give different ASE values. An example of such a result is below. In this case we record the worst performing ASE value.

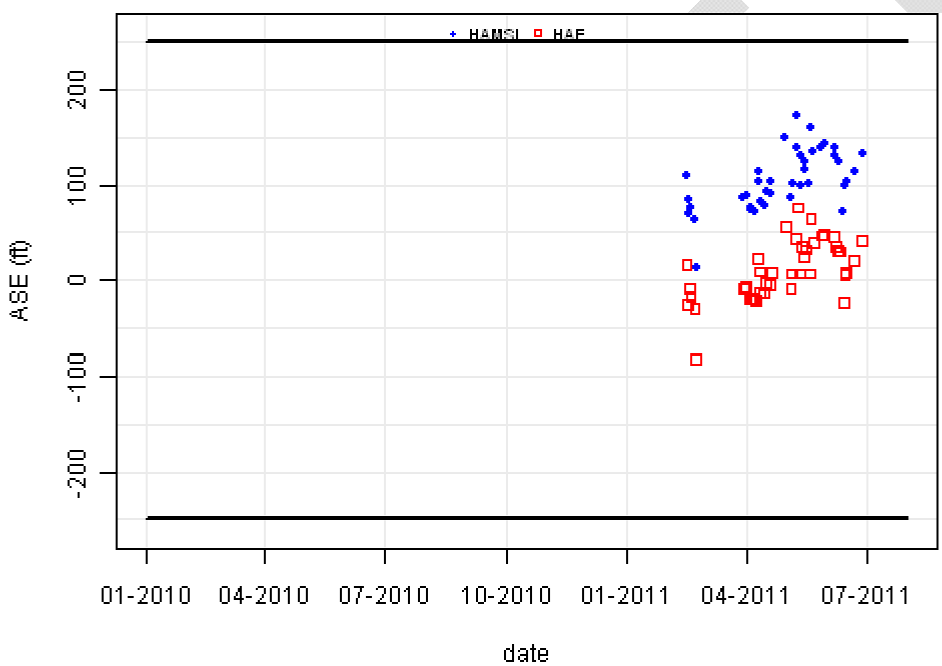


A.10 Some airframes give ASE data with a significant trend. This indicates a degrading of the altimetry system not the GPS system. The example below shows a steady region, followed by a decline in ASE performance followed by a distinct change, which may be due to maintenance. In the case below we would record an ASE of -60 feet corresponding to the system after the maintenance.



A.11 In calculating ASE values it is necessary to determine which geoid reference the GNSS (GPS) system is using. This is either Height Above Ellipsoid (HAE) or Height Above Mean Sea Level (HAMSL). Aircraft manufacturers and aircraft operators are generally unaware which height reference their avionics uses since geometric height is not used by an FMS. We have mathematical methods to determine which is being used, and in general it is obvious after processing the data. However, for certain airframes the geoid assumption is difficult to determine. In these cases we refer to other similar airframes using similar avionics and GNSS systems.

The example below indicates such an airframe with the blue (HAMSL) being our estimate of the correct geoid and set of ASE values (blue).



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Appendix B: Details for all airframes – ordered by Mode S

Detailed analysis of all airframes, along with fleet comparisons is done in the attached HTML file. The date is the last monitoring date for this airframe. The ASE is in feet.

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ref number	Mode-s	Reg	operator	type	ASE	date	no. days	no points
326			XXX	B744-5	-69	16/02/2010	1	3631
327			XXX	B744-5	-46	14/02/2011	12	45582
328			XXX	B744-5	-48	31/01/2011	16	64779
329			XXX	B744-5	-103	31/01/2011	23	103357
330			XXX	B744-5	-146	26/01/2011	14	58896
331			XXX	B744-5	-78	2/05/2011	16	99032
332			XXX	B744-5	-38	6/03/2011	16	75397
333			XXX	B744-5	-100	4/01/2011	17	67156
334			XXX	B744-5	-27	13/01/2011	21	78996
335			XXX	B744-10	-65	19/01/2011	26	106770
336			XXX	B744-10	-100	16/05/2011	19	117923
337			XXX	B744-10	-100	21/01/2011	10	45320
338			XXX	B744-10	-50	15/01/2011	18	74100
339			XXX	B744-10	-63	27/01/2011	22	90046
340			XXX	B744-10	-132	30/01/2011	16	70002
341			XXX	B744-10	-81	8/02/2011	21	81357
342			XXX	B744-10	-93	6/06/2011	10	58036
343			XXX	B744-10	-73	10/04/2011	9	32349
344			XXX	B744-10	-50	28/01/2011	16	60521
345			XXX	B744-10	-117	27/06/2011	14	79302
346			XXX	B744-10	-120	17/03/2011	19	112948
347			XXX	B744-10	-129	14/12/2010	12	73079
348			XXX	B744-10	-60	29/03/2011	14	92835
349			XXX	A330	-24	19/01/2011	7	36108
350			XXX	A330	24	17/01/2011	3	24276
351			XXX	A330	5	22/12/2010	2	6010
352			XXX	A330	10	31/01/2011	445	3670725
353			XXX	A330	16	31/01/2011	443	3715826
354			XXX	A330	23	31/01/2011	428	3629949
355			XXX	A330	30	31/01/2011	449	3743189

Example of ASE data and graphs for an individual operator provided by AAMA.

ASE 10/8/2011

This is an automatically generated report on ASE calculations based on Australian ADS-B data.

The html versions of this report are hyperlinked: click on the navigation line, particular airframes or aircraft types to move to that part of the document. Pdf versions of this document will have internal hyperlinks enabled but not external links.

Figures are hyperlinked and clicking on a figure will bring up the original .png file.

Tables can be cut and paste easily into an excel spreadsheet.

Depending on the report version there will be links to 'problem aircraft' (airframes identified as requiring investigation); 'summary table' a list of all airframes and reference details; or 'types' a breakdown of all airframes by aircraft type.

A brief explanation of the ASE processing is give in Airframe_Notes.pdf
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Operator: XXX, XXXX Airways

Summary Table

row	internal number	hex	reg	operator	type	ASE	last date	approved	no. days	no. points	comment
1	326	XXXXX	ABC	XXX	B744-5	-69	2010-02-16	YES	1	3631	-
2	327	YYYY	DEF	XXX	B744-5	-46	2011-02-14	YES	12	45582	-
3	328	UUUU	GHI	XXX	B744-5	-48	2011-01-31	YES	16	64779	-
4	329	WWWW	JKL	XXX	B744-5	-103	2011-01-31	YES	23	103357	-

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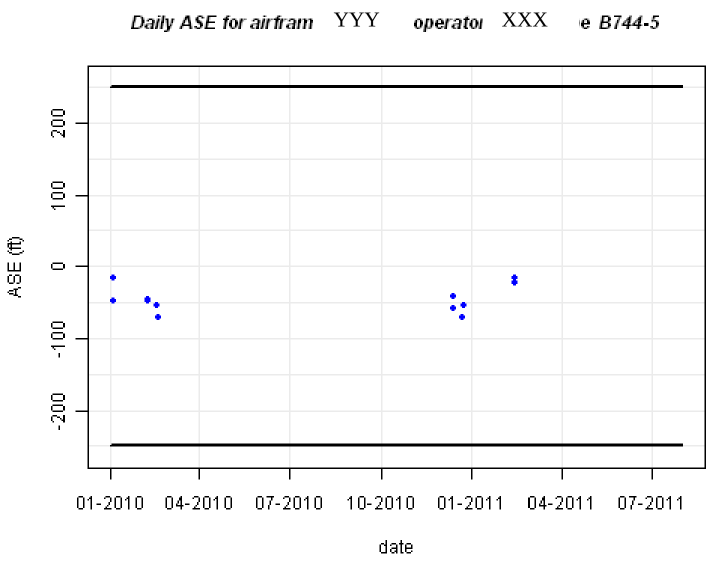
Daily ASE values for all Airframes

327_ YYYY

row	internal number	hex	reg	operator	type	ASE	last date	approved	no. days	no. points	comment
327	327	YYYY	DEF	XXX	B744-5	-46	2011-02-14	YES	12	45582	-



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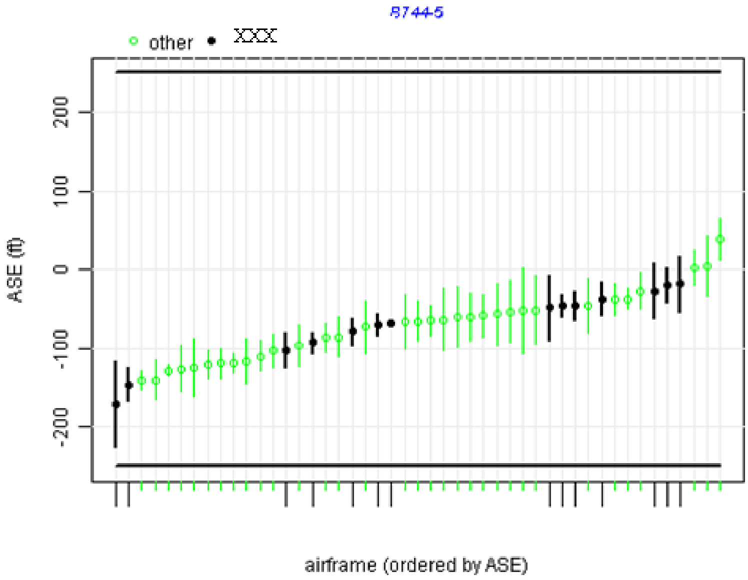
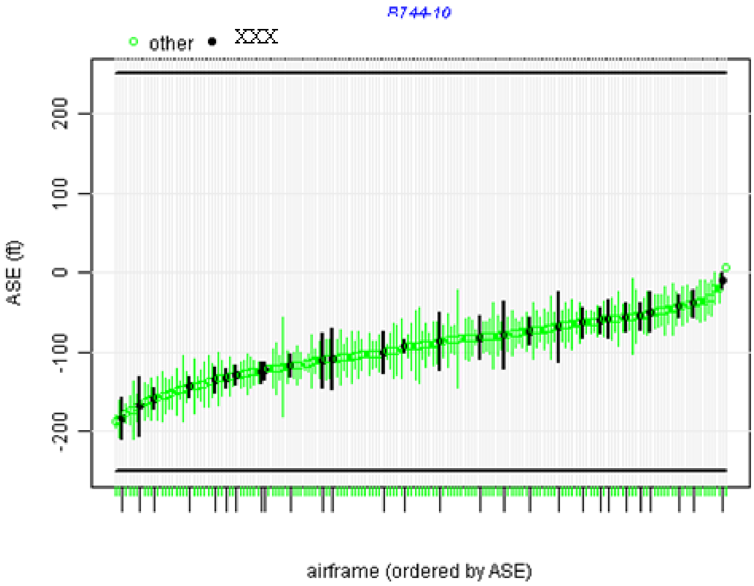
Airframe Types

B744-5



row	internal number	hex	reg	operator	type	ASE	last date	approved	no. days	no. points	comment
1	326	ZZZZZ	MNO	XXX	B744-5	-69	2010-02-16	YES	1	3631	+
2	327	CCCCC	JKL	XXX	B744-5	-46	2011-02-14	YES	12	45582	+
3	328	RRRRR	EST	XXX	B744-5	-48	2011-03-03	YES	16	64779	+

B744-10



row	internal number	hex	reg	operator	type	ASE	last date	approved	no. days	no. points	comment
1	335	NNNNN	WXY	XXX	B744-10	-55	2011-02-24	YES	26	106770	+
2	336	TTTTT	VST	XXX	B744-10	-100	2011-05-16	YES	19	117923	+
3	337	MMMMM	QAX	XXX	B744-10	-78	2011-05-15	YES	10	45320	+

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