International Civil Aviation Organization

The 18th Meeting of the Regional Airspace Safety Monitoring Advisory Group (RASMAG/18)

Bangkok, Thailand, 01 – 04 April 2013

Agenda Item 3: Reports from Asia/Pacific RMAs and EMAs

DATA SHARING BETWEEN STATES AND RMAs

(Presented by Australia)

SUMMARY

This paper presents a brief discussion of the benefits of data sharing and cooperation between RMAs in terms of determining the Altimetry System Error (ASE) for an aircraft.

This paper relates to –

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

Global Plan Initiatives:
GPI-2 Reduced vertical separation minima
GPI-8 Collaborative airspace design and management

1. INTRODUCTION

1.1 This paper discusses the benefits of cooperation and data sharing amongst RMAs, in the context of determining the Altimetry System Error of aircraft.

1.2 The attached appendix contains a Working Paper from RMACG 8 (April 8-12, 2013) on the benefits of RMA cooperation. It shows that data sharing allows an accurate determination of the aircraft's geoid height reference as Height Above Mean Sea Level (HAMSL) or Height Above Ellipsoid (HAE) whereas data from each RMA alone would be insufficient. Additionally obtaining data from a wide range of geographic locations enables a more robust averaging of ASE which can be biased if sampled from the same region or times of day.

2. DISCUSSION

2.1 The appendix gives clear examples of how data sharing between RMAs has benefits in terms of determining the geoid height reference for each aircraft. This reference is crucial in establishing the ASE of an aircraft and cannot be established without obtaining data from a wide range of geographic locations.

2.2 The attached **Appendix A** also gives detail on preferred data sharing formats to enable easy cooperation between RMAs including sharing of final ASE estimates.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) note the information contained in this paper; and

b) discuss any relevant matters as appropriate.

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International Civil Aviation Organisation

WORKING PAPER

**REGIONAL MONITORING AGENCY COORDINATION GROUP (RMACG)
WORKING GROUP MEETING**

Eigth MEETING

Canberra, Australia, April 2013

Agenda Item 1: XX

DATA SHARING BETWEEN STATES AND RMAS

(Presented by Robert Butcher)

(Prepared by AAMA)

Summary

This paper considers the benefits of regional RMA cooperation in determining Altimetry System Error (ASE) from ADS-B. Cooperation allows for accurate determination of the geoid height reference being used by the aircraft which can greatly affect the abilty to find a distinct ASE. The error in ASE values are smaller when a large number of independent data sets are found. Hence cooperation between RMA's can allow for a more accurate measure of ASE. This paper also considers formats for inter-agency exchange of data.

1 INTRODUCTION

1.1 This paper considers the benefits of RMA cooperation in determining ASE values and increasing the accuracy of these values.

1.2 Previous work has shown that ASE values found from ADS-B data require a knowledge of the geiod height reference used by the aircraft; as either Height Above Mean Sea Level (HAMSL) or Height Above Ellipsoid (HAE). While statistical tests have been developed for finding this geoid reference from ADS-B data, it relies on ASE values calculated from a wide range of geographical locations with a HAMSL-HAE difference. The greater the range of this geoid difference the easier the estimation of the geoid reference.

1.3 Previous work has also shown that there can be bias in ASE values according to time of day and geographic location. Averaging over a wide range of locations and times hence improves the accuracy of the ASE results and regional cooperation can facilitate this.

1.4 This work is the natural continuation of earlier research by the authors [1, 2, 3, 4, 5, 6, 7].

2 METHODOLOGY

2.1 The AAMA data was divided into that obtained from Airservices ADS-B network and data from a small number of ground-stations in Indonesia (Bali) but used by Australian ATC. Aircraft that were seen only in this Indonesian data were not examined in our height keeping. Data from the Indonesian ground stations were used as part of the ASE analysis for aircraft also seen in Australia, in order to assist in determining the geoid height reference.

2.2 In December 2012 MAAR visited the AAMA and provided a snapshot of their current ASE results. In February 2013 China RMA (China RMA), AAMA and MAAR cooperated in evaluating China RMA 's capability to calculate ASE from ADS-B. The following figures represent *approximations* of some numerical counts, in order to give an indication of the number of aircraft for which co-operation would be beneficial.

- $\sim$ 1800 = number of aircraft in AAMA sample
- $\sim$ 2300 = number of aircraft in MAAR sample
- $\sim$ 1150 = number of aircraft in AAMA's Indonesian sample
- $\sim$ 2100 = number of aircraft in combined AAMA and Indonesian sample (AAMA/IND)
- $\sim$ 3400 = number of China RMA aircraft
- $\sim$ 1000 = number of common aircraft in AAMA and MAAR samples
- $\sim$ 1200 = number of aircraft in common with AAMA/IND and MAAR
- $\sim$ 850 = number of common aircraft in AAMA and Indonesian samples

- $\sim$ 800 = number of common aircraft in Indonesian and MAAR samples
- $\sim$ 1000 = number of common aircraft in AAMA/Ind and China RMA samples
- $\sim$ 1800 = number of common aircraft in MAAR and China RMA samples
- $\sim$ 3700 = number of aircraft in combined AAMA, MAAR and Indonesian data sets

3 GEOID DETERMINATION

3.1 For AAMA data we can usually determine the geoid reference for an aircraft from our own data. However, in numerous cases (which I cannot quantify) we found that data from MAAR and from China RMA enabled us to determine the geoid from the combined data sets, where each individually meant this was difficult.

3.2 Figures 1, 2, and 3 represent results for a single aircraft, using results from the combined RMAs and the China RMA and MAAR separately. These graphics are designed to help in our determination of geoid and ASE values.

3.3 The top left plot of Figure 1 shows the daily ASE averages versus date with blue squares the ASE(HAMSL) and the red circles the ASE(HAE). Thre is little indication from this of the correct ASE value or the geoid.

3.4 The top right plot of Figure 1 shows ASE values averaged over each geoid difference (HAMSL-HAE). Here it is apparent that the aircraft is using HAMSL since this does not vary with geoid difference (slope is zero) while the incorrect measure, HAE, has a slope of -1.

3.5 The bottom left plot of Figure 1 shows the distributions of ASE. From this plot it is not clear what the correct ASE or geoid is.

3.6 The bottom right plot of Figure 1 plots of the routes on a map with the points in the South China Sea from China RMA and the data from Thailand (MAAR) and Australia (AAMA) apparent.

3.7 Figure 1 indicates the ASE is 33 ft with the main estimates being 24 to 41 feet. Hence the combined sample provides an accuracy of $\pm$ 10 ft.

3.8 Figures 2 and 3 represent results from China RMA and MAAR data respectively. In each case the individual data is insufficient to determine the geoid. However, as a combined set the geoid is easily determined and the ASE correctly found.

3.9 Figure 2 has a limited set of data and hence the top right plot of ASE versus geoid plots each data point rather than the mean. Note that these flights are within the region where HAMSL HAE and hence both ASE(MSL) and ASE(HAE) are similar. However, given the limited data any result will only by $\pm$ 100 ft or more.

3.10 Figure 3 has a lot of data but from a small geographical region, hence determination of the geoid is difficult and the estimation of ASE could be either 35 ft or 120 ft. This is compared with our combined data set which has an estimate of 33 $\pm$10 ft.

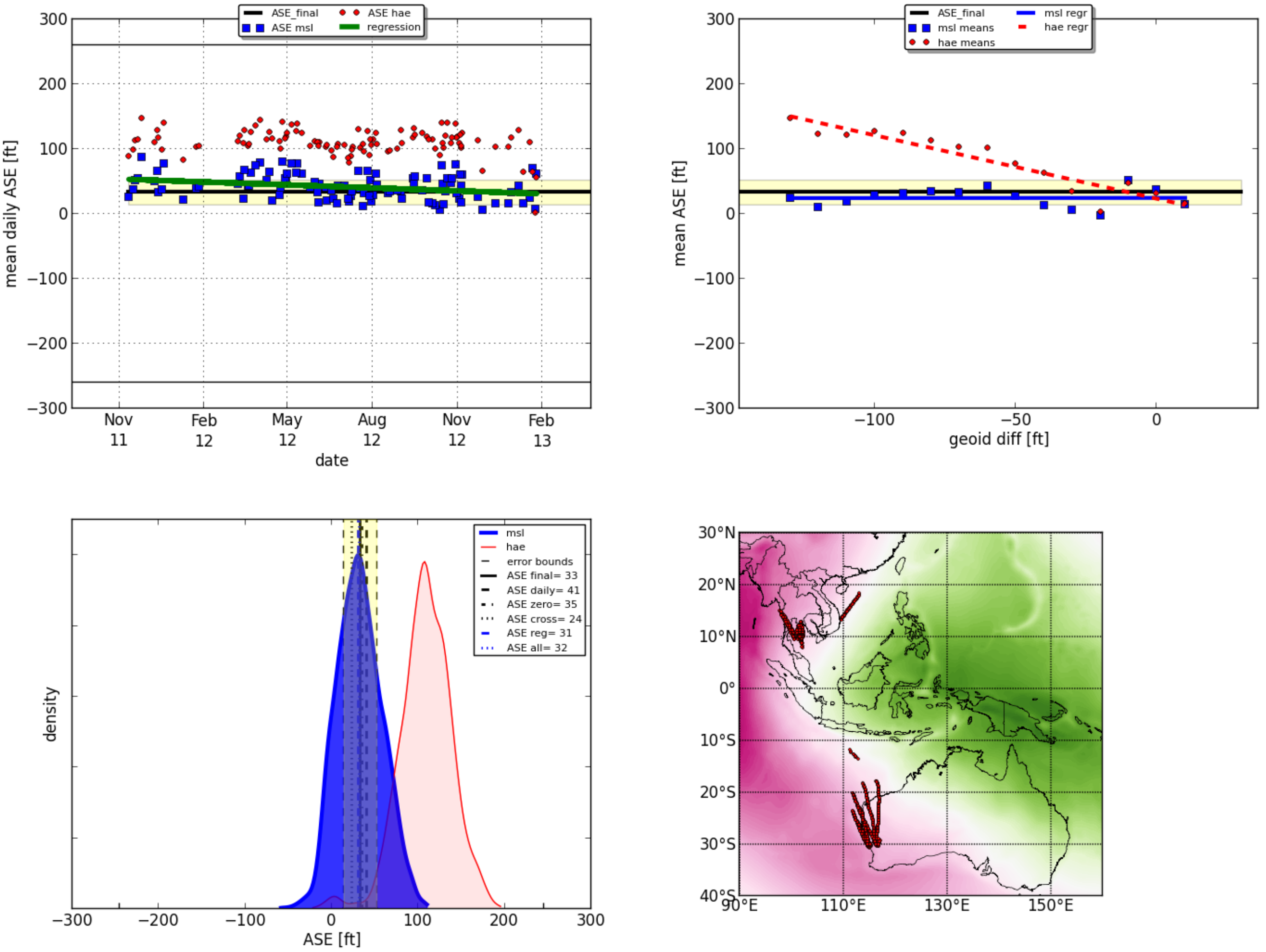

Figure 1: ASE traces using AAMA/MAAR/China RMA data. The top left plot are the daily ASE averages versus date with blue squares the ASE(HAMSL) and the red circles the ASe(HAE). The top right plot are ASE values averaged over each geoid difference. The bottom left plot are the distributions of ASE and the bottom right the plots of the routes.

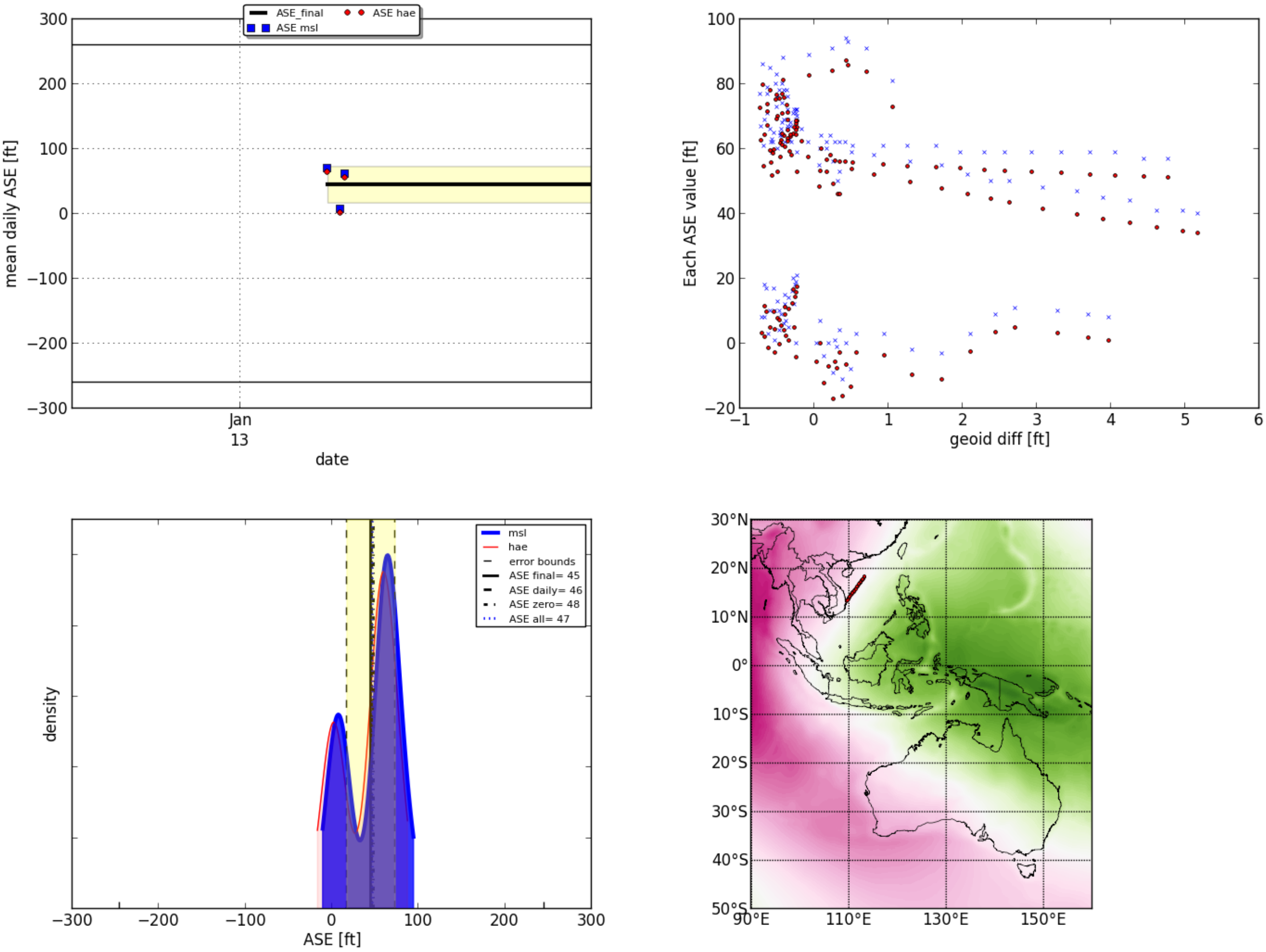

Figure 2: ASE traces using China RMA data. The top left plot are the daily ASE averages versus date with blue squares the ASE(HAMSL) and the red circles the ASE(HAE). The top right plot are ASE values at each point versus geoid difference. The bottom left plot are the distributions of ASE and the bottom right the plots of the routes.

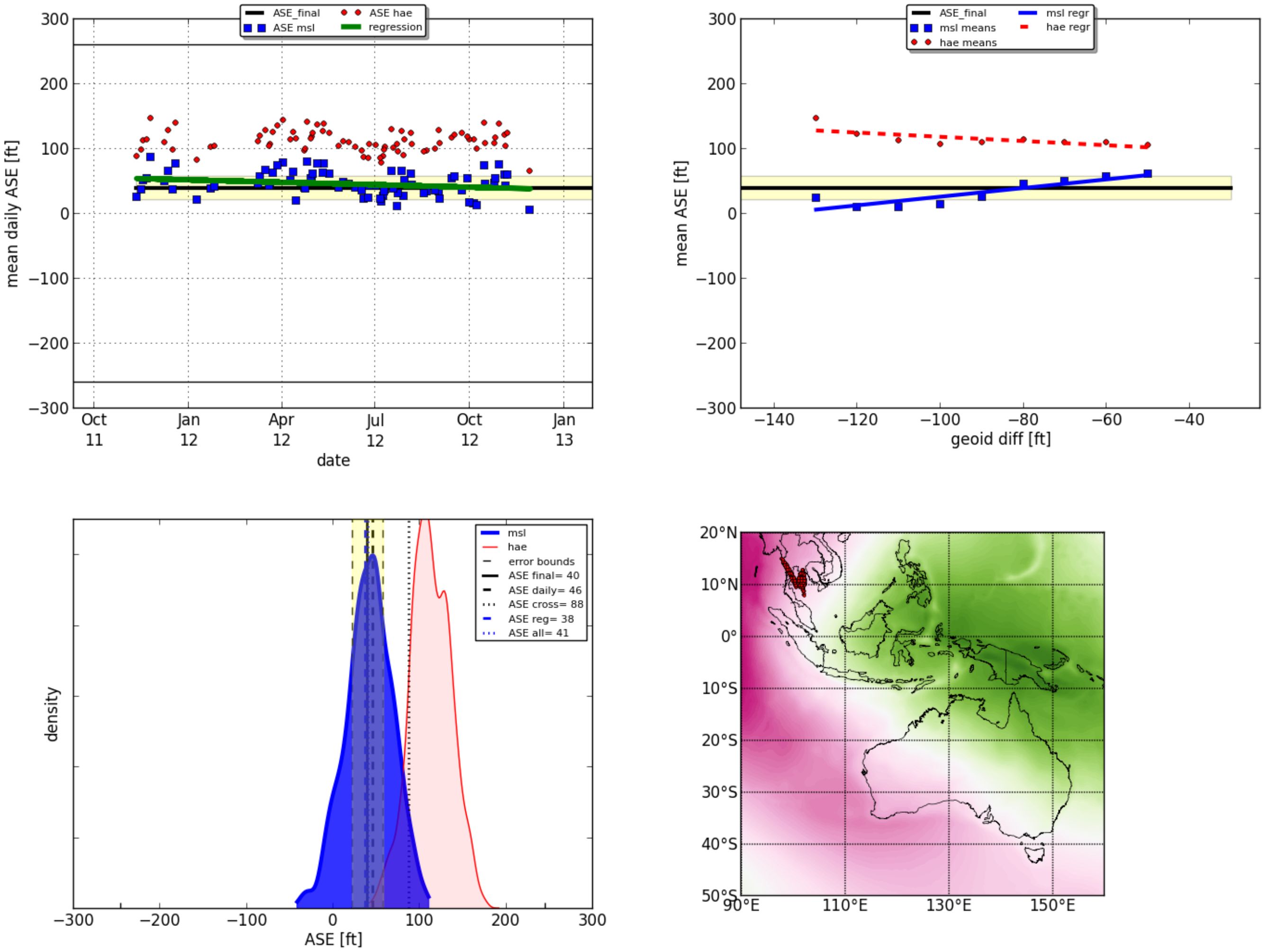

Figure 3: ASE traces using MAAR data. The top left plot are the daily ASE averages versus date with bluesquares the ASE(HAMSL) and the red circles the ASe(HAE). The top right plot are ASE values averaged over each geoid difference. The bottom left plot are the distributions of ASE and the bottom right the plots of the routes.

4 DATA SHARING

4.1 AAMA is developing code to easily handle data from different RMA's. AAMA's preferred format is for each aircraft to have a separate .csv data file with data separated into fields:

- yr = the year
- mn = the month
- dy = the day
- sec = seconds since start of day
- lat = latitude in degrees
- lon = longitude in degrees
- ASE_MSL = ASE determined assuming HAMSL
- ASE_HAE = ASE determined assuming HAE
- AAD = assigned altitude deviation
- ASE_MSL_cor = corrected ASE_MSL (can be left blank or the same as ASE_MSL)
- cor_time = correction for diurnal time variation (can be left blank or zero)
- cor_date = correction for date (an be left blank or zero)
- RMA = integer or string, ie 1=AAMA, 2=Indonesia, 3=MAAR, 4=China RMA , or can be left blank.

4.2 Each file name has the name 'hxABC123.txt' where 'ABC123' is the ICAO mode-s hex address. The addition of 'hx' in the title helps prevent some problems with later analysis when aircraft like 00B0F1 are shortened to B0F1 or aircraft with hex code 1234E12 are reflected in excel as 1234 $\times 10^{12}$.

4.3 An example of a file is as below:

```
yr,mn,dy,sec,lat,lon,ASE_MSL,ASE_HAE,AAD,N,ASE_MSL_cor,cor_time,cor_date,RMA
2012,12,30, 46007,-8.8858,146.7042,133,-108,-22.0,11,136,0,0,1
2012,12,30, 46074,-9.0262,146.7047,120,-120,-22.0,16,123,0,0,1
2012,12,30, 46146,-9.1781,146.7054,129,-108,-22.0,27,132,0,0,1
2012,12,30, 46206,-9.3047,146.7058,127,-109,-22.0,25,137,0,0,1
2012,12,30, 46267,-9.4318,146.7063,108,-125,-22.0,28,118,0,0,1
2012,12,30, 46325,-9.5537,146.7068,105,-127,-22.0,33,115,0,0,1
2012,12,30, 46386,-9.6812,146.7072,110,-121,-21.8,33,120,0,0,1
```

4.4 These files can be compressed and sent via email or via a dedicated secure server.

4.5 It is also useful to have database information on current aircraft in our systems. The simple format used by AAMA is a single .csv file of the form:

1. name = an internal numbeirng system, ie N000111
2. hx = hex code, ie hxCABC12
3. reg = registration, ie VHABC
4. type = monitoring group, ie A320
5. type2 = aircraft type, ie A322
6. serial = serial number, ie 12345
7. series = series, ie A322-400F
8. operator ie QLF
9. operator_ful,l ie Qantas
10. stat,e ie Y
11. state_ful,l ie Australia
12. geoid = the geoid choice, ie MSL or HAE or VAR
13. date_start = the first date of monitoring, ie 1/1/2012
14. date_change = when a distinct change in ASE trace was observed, ie 1/11/2012
15. date_finish = last date of monitoring, ie 1/2/2013
16. N_sec = number of seconds of data, ie 86400
17. N_points = number of data points, ie 8430
18. N_days = number of days of data, ie 5
19. other fields as necessary

4.6 Our csv file also includes fields for our different estimates of ASE values, a test for the geoid and so on.

4.7 Note that a geoid choice of 'VAR' indicates an aircraft which switches geoid reference between HAMSL and HAE.

4.8 Sharing of these files in a common format can allow for us to identify common aircraft and to spot errors in our respective results and data.

5 DISCUSSION

5.1 AAMA, MAAR and China RMA have cooperated on some ad-hoc data sharing in 2012 and 2013. This have been of enormous assistance to the AAMA in helping us refine our systems and check some of our geoid assumptions.

5.2 It would prove useful for this cooperation to be formalised and extended to other RMAs. Currently we have shared data through email exchanges however setting up a secure data exchange mechanism would be useful but would require some work from our respective Information Technology departments. Another data sharing method would be for these files to be stored on a centrally accessible server, and updated as necessary by the RMAs.

5.3 The logistics of this cooperation may be constrained by the file sizes, which can be as high as 7 MB for a single aircraft with a years worth of data. We currently have 4.2 GB of data for three years. This is in unzipped format.

5.4 One simple solution is for data to be encrypted and stored on a central data warehouse (such as Google Docs, DropBox or similar). The cost of this storage would be approximately $100 per year but would enable easy access to data for all defined users with the password.

5.5 The data formats outlined above are a suggestion from the AAMA, as we currently use this format in our processing and find it convenient and simple. It would be a simple matter for us to adjust our code to a different format, but we do see the benefit of different RMA's agreeing on a common format.

6 ACTION PROPOSED

6.1 The Meeting is invited to review and discuss.

7 ACKNOWLEDGMENTS

AAMA would like to acknowledge the assistance of MAAR and the China RMA in this cooperation. The ASE processor used by the AAMA was developed by the FAA and the use of this in our analysis is greatly appreciated.

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