International Civil Aviation Organization

THE NINTH MEETING OF THE SOUTHEAST ASIA AND BAY OF BENGAL SUB-REGIONAL ADS-B IMPLEMENTATION WORKING GROUP (SEA/BOB ADS-B WG/9)

Beijing, China, 30 October - 1 November 2013

Agenda Item 6: Need for Monitoring and Improvement in Compliance

SYSTEMATIC PERFORMANCE MONITORING OF ADS-B EQUIPPED AIRCRAFT, AND SHARING OF THE MONITORING RESULTS FOR THE APAC REGION

(Presented by Hong Kong China)

SUMMARY

This paper re-capped the systematic algorithm proposed by Hong Kong China during ADS-B SITF/12 to monitor avionics performance of ADS-B aircraft, and the scheme for States/Administrations to report problems under defined categories, share monitoring results to a centralized database, and "blacklist" problematic aircraft. As discussed during the APANPIRG in its 24th meeting, assistance was sought from the ICAO Regional Sub-office to establish a centralized database for promulgating ADS-B performance monitoring and analysis results for enhancing aviation safety of the region.

Hong Kong China shared its analysis results on ADS-B equipped aircraft flying within the Hong Kong Flight Information Region (HKFIR) captured for the past nine months, and identified three major categories of problems requiring actions from concerned CAAs/operators. Considering wide extent of the problems, it is proposed that a post ADS-B mandate period of 9 - 12 months be given to airline operators to rectify their problems, and for States to subsequently collect data and conduct safety assessment, leading to deployment of ADS-B for operational use.

1. INTRODUCTION

1.1 During the ADS-B SITF/12 held in April 2013, Hong Kong China presented a working paper (WP/16) to put forward a systematic algorithm based on an independent surveillance source (e.g. radar) and flight plan information to monitor and analyse avionics performance of ADS-B equipped aircraft, and a scheme for reporting problems and blacklisting aircraft. The WP was well received and the TF agreed to study the proposed algorithm and scheme in further details and would consider incorporating it as guidance material into the AIGD.

1.2 During the APANPIRG/24 held in June 2013, the following Conclusion was endorsed to encourage States/Administration to exchange their ADS-B performance monitoring results and experience gained from the process:

Conclusion 24/45 - Exchange ADS-B Performance Monitoring Result

"That, States be encouraged to exchange findings/result of their ADS-B performance monitoring including experience gained in conducting the required performance monitoring."

1.3 Besides, the APANPIRG/24 also requested the ICAO Secretariat to seek possibility of establishing a centralized database for sharing the monitoring results at the ICAO Regional Sub-office (RSO).

1.4 This paper further elaborated the systematic algorithm and monitoring scheme steered by Hong Kong China, and highlighted the analysis results based on the ADS-B flight information so collected within the HKFIR from December 2012 to August 2013 (nine months).

2. DISCUSSION

Systematic Algorithm for ADS-B Performance Monitoring

2.1 The ADS-B ground station infrastructure in Hong Kong China has been progressively built since early 2013 with its data feeding into an ADS-B data monitoring and analysis trial system.

2.2 At the beginning of each month, the system will intake all recorded information on ADS-B, radar targets and ATS flight plans within the HKFIR for the past one month in an offline manner. For each ADS-B flight, the system will compare it with its corresponding radar and flight plan information, and analyse if the following pre-defined criteria are met :-

(a) Deviation between ADS-B reported position and independent referenced radar position is greater than 1NM for more than 5% of total number ADS-B updates within the HKFIR; or

(b) Navigation Uncertainty Category (NUC) of each ADS-B reported position is smaller than 4 for more than 5% of total number of ADS-B updates within the HKFIR; or

(c) Flight Identification (FLTID) entered via cockpit interface and downlinked in ADS-B data (i.e. I021/170 in Asterix CAT 21) does not match with aircraft callsign in the ATS Flight Plan for more than 5% of total number of ADS-B updates within the HKFIR.

2.2.1 For 2.2 (a) above, deviation between ADS-B and radar tracks has been set to 1NM in accordance with ICAO Circular 326 defining position integrity (NUC) shall be at least 4 (0.5NM < HPL < 1NM) for 3NM aircraft separation use, on assumption that radar targets are close to actual aircraft position. A threshold of 5% is initially set to exclude aircraft only exhibiting occasional problems during their flight journey within HKFIR. All the above criteria are configurable to allow fine-tuning in future.

2.2.2 The system will generate a list of aircraft meeting the above pre-defined criteria showing full details of each occurrence such as date/time of occurrence, Mode S address, screen capture of radar and ADS-B history tracks, graphs of NUC value changes and deviation between radar and ADS-B tracks along the flight journey (see Appendix 1). The system has monitored and analysed over 350,000 ADS-B flight movements, including more than 4,000 ADS-B equipped aircraft, for the past 9 months from December 2012 – August 2013 within the HKFIR, and identified three major categories (CAT 1 to CAT 3) of problems as shown in Appendix 2.

Scheme for Problem Reporting, Promulgation and Blacklisting

2.2.3 For the list of aircraft under CAT 1 with large deviation between ADS-B and radar tracks but good NUC (6 nos. of aircraft), it is recommended that monitoring results be shared with other States capable of performing ADS-B monitoring and analysis to verify the findings. Once verified, the list should then be promulgated on a central database for sharing with all parties, while concerned CAAs/operators should take immediate remedial actions. Before the problem is rectified, ANSPs might consider to "blacklist" those aircraft from their ground systems to minimize safety impacts to ATC operations.

2.2.4 For the list of aircraft under CAT 2 with inconsistent FLTID (45.2% aircraft), it is recommended that the monitoring results be promulgated on the central database. CAAs concerned should follow up the airworthiness issue with airline operators in question urging them for early rectification. For aircraft showing no improvement on persistent incorrect FLTID after notification, ANSPs might consider to "blacklist" them from their ground systems.

2.2.5 For the list of aircraft under CAT 3 with constant NUC = 0 (13.7% aircraft), although they do not have direct safety implication assuming the ground systems could discard ADS-B data with low NUC values, concerned airline operators are required to take early remedial actions. Otherwise, their aircraft will be treated as if non-ADS-B equipped to fly outside the ADS-B airspace after the ADS-B mandate becomes effective.

2.2.6 Assistance from ICAO is sought to establish a centralized database for storing and promulgating monitoring and analysis results of ADS-B equipped aircraft in the region.

2.3 Based on the monitoring and analysis results, it is observed that ADS-B equipped aircraft having incorrect FLTID (CAT 2) or constant NUC = 0 (CAT 3) are not uncommon for the region. Considering wide extent of the problems, it is recommended that States having intent to mandate ADS-B should commence their early monitoring/analysis work, and report problems to concerned CAAs/airline operators for early rectification. A period of 9 - 12 months post ADS-B mandate is considered prudent to allow States to continue their assessment, collect ADS-B performance data, conduct safety assessment, while allowing sufficient time for airline operators to rectify their avionics problems, and making good preparation by all stakeholders for operational use of ADS-B technology.

3. ACTION BY THE MEETING

3.1 The meeting is invited to:

a) note that Hong Kong China has steered to propose an algorithm to systematically monitor performance of ADS-B equipped aircraft based on independent surveillance source, and a scheme to (i) analyse and report problems into three major categories, (ii) share analysis results to a centralized database and (iii) "blacklist" problematic aircraft;

b) encourage States who are capable of performing monitoring and analysis of ADS-B equipped aircraft to share their analysis results according to the proposed algorithm/scheme;

c) note the possible safety implications as identified by Hong Kong China on ADS-B aircraft avionics performance, and deliberate a post ADS-B mandate period of 9 - 12 months for better preparation by stakeholders on operational use of ADS-B;

d) formulate a draft Conclusion to adopt the proposed algorithm and analysis scheme into the AIGD as guidance materials; and

e) seek assistance from ICAO to establish a centralized database for storing and promulgating ADS-B performance monitoring and analysis results for enhanced aviation safety of the region.

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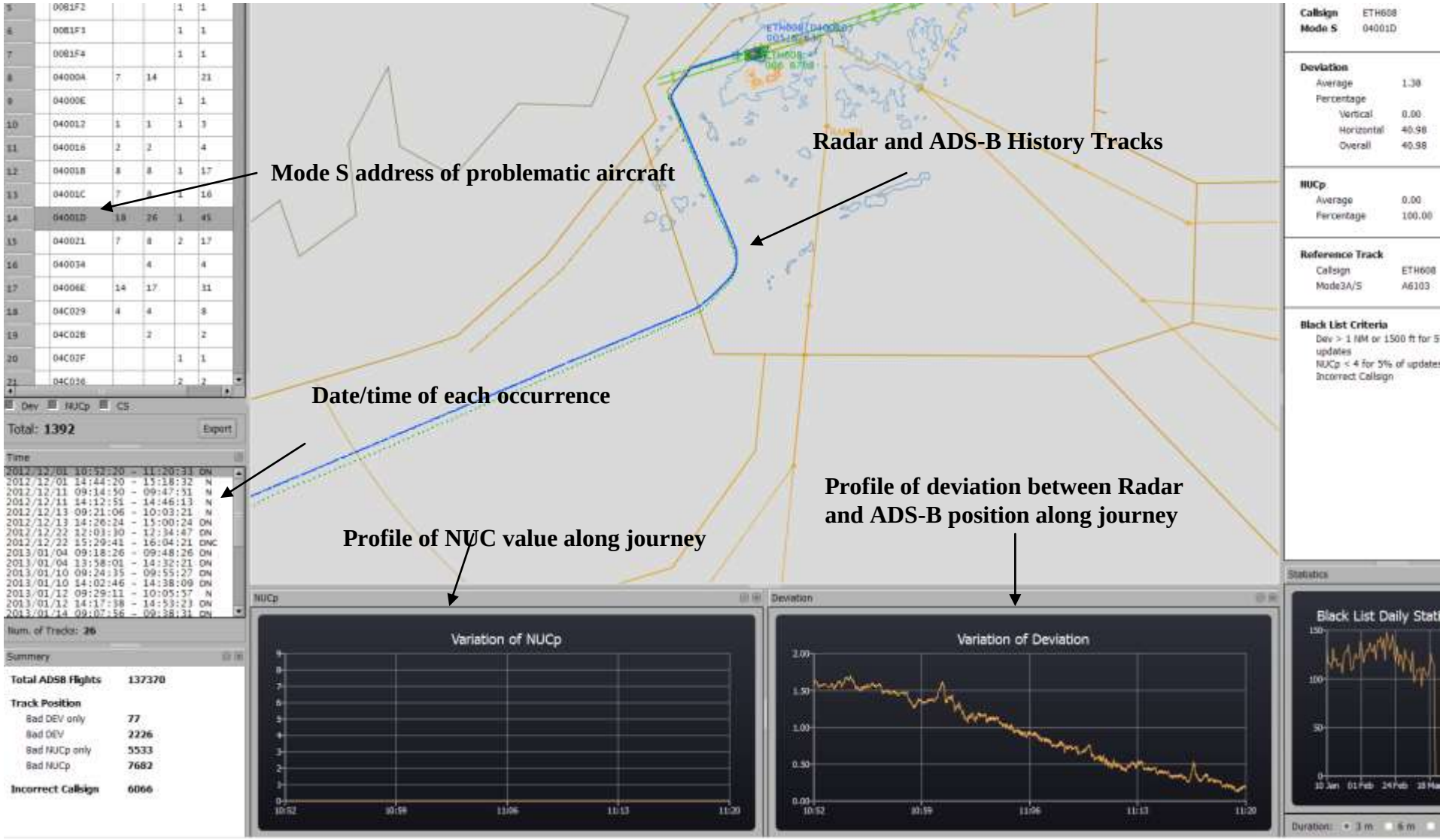
Appendix 1


Mode S address of problematic aircraft
Radar and ADS-B History Tracks
Date/time of each occurrence
Profile of deviation between Radar and ADS-B position along journey
Profile of NUC value along journey
Variation of NUCp
Variation of Deviation
Total: 1392
Export
Num. of Tracks: 26
Total ADS8 Flights 137370
Track Position
Bad DEV only 77
Bad DEV 2226
Bad NUCp only 5533
Bad NUCp 7682
Incorrect Callsign 6066
Callsign ETH608
Mode S 04001D
Deviation
Average 1.38
Percentage
Vertical 0.00
Horizontal 40.98
Overall 40.98
NUCp
Average 0.00
Percentage 100.00
Reference Track
Callsign ETH608
Mode3A/S A6103
Black List Criteria

Appendix 2

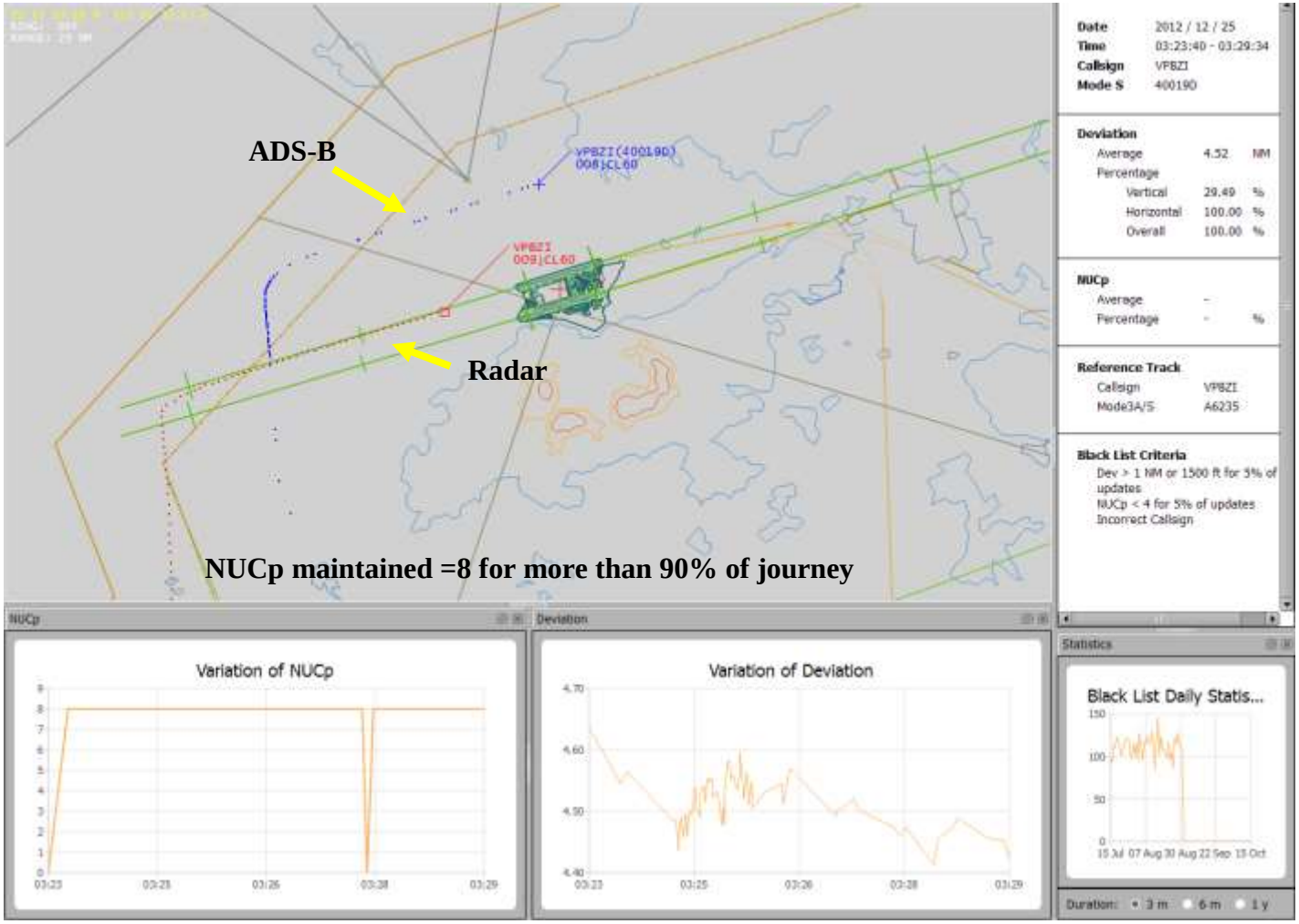
Monitoring and Analysis Results of ADS-B Equipped Aircraft flying inside the HKFIR from December 2012 – August 2013

Category	Description	Safety implications to ATC (Yes/No)	Statistics	Recommendation
Cat. 1	ADS-B position report with good integrity (i.e. NUC >= "4") but ADS-B position data are actually bad as compared with radar (meeting criterion 2.2(a)).	**Yes.** The ground system could not "automatically" discard ADS-B data with good integrity (i.e. NUC value >=4).	6 aircraft (1 local and 5 foreign registered) have been detected under this category. Typical examples are given in Appendix 3a – 3c.	(i) The problem should be immediately reported to the concerned CAA/operators for rectification before the ADS-B data could be used by ATC. (ii) Consider to "blacklist" the aircraft before the problem is rectified.
Cat. 2	FLTID transmitted by ADS-B aircraft does not match with callsign in flight plan.	**Yes.** Could lead to screen clutter - two target labels with different IDs (one for radar and another for ADS-B) being displayed, causing potential confusion and safety implications to ATC.	15,598 (4.4%) ADS-B flights, or 1,827 aircraft (45.2%) are identified under this category. Typical examples are given in Appendix 4.	(i) Issue regulations / letters to concerned operators urging them to set FLTID exactly match with callsign in flight plan. (ii) Consider to "blacklist" the aircraft should no improvement be shown after notification.
Cat. 3	ADS-B position report with no integrity (i.e. NUC always "0").	**No.** The ADS-B data with NUC = 0 will be discarded by the ground system and the aircraft would be treated as if they were non-equipped.	16,612 (4.6%) ADS-B flights, or 555 ADS-B aircraft (13.7%) monitored are identified under this category. Typical examples are given in Appendix 5a – 5d.	Concerned operators should initiate prompt action for rectification, otherwise they might be requested to fly outside ADS-B airspace.

Note : 358,386 ADS-B flight movements (or 4042 nos. ADS-B equipped aircraft) were monitored from December 2012 - August 2013

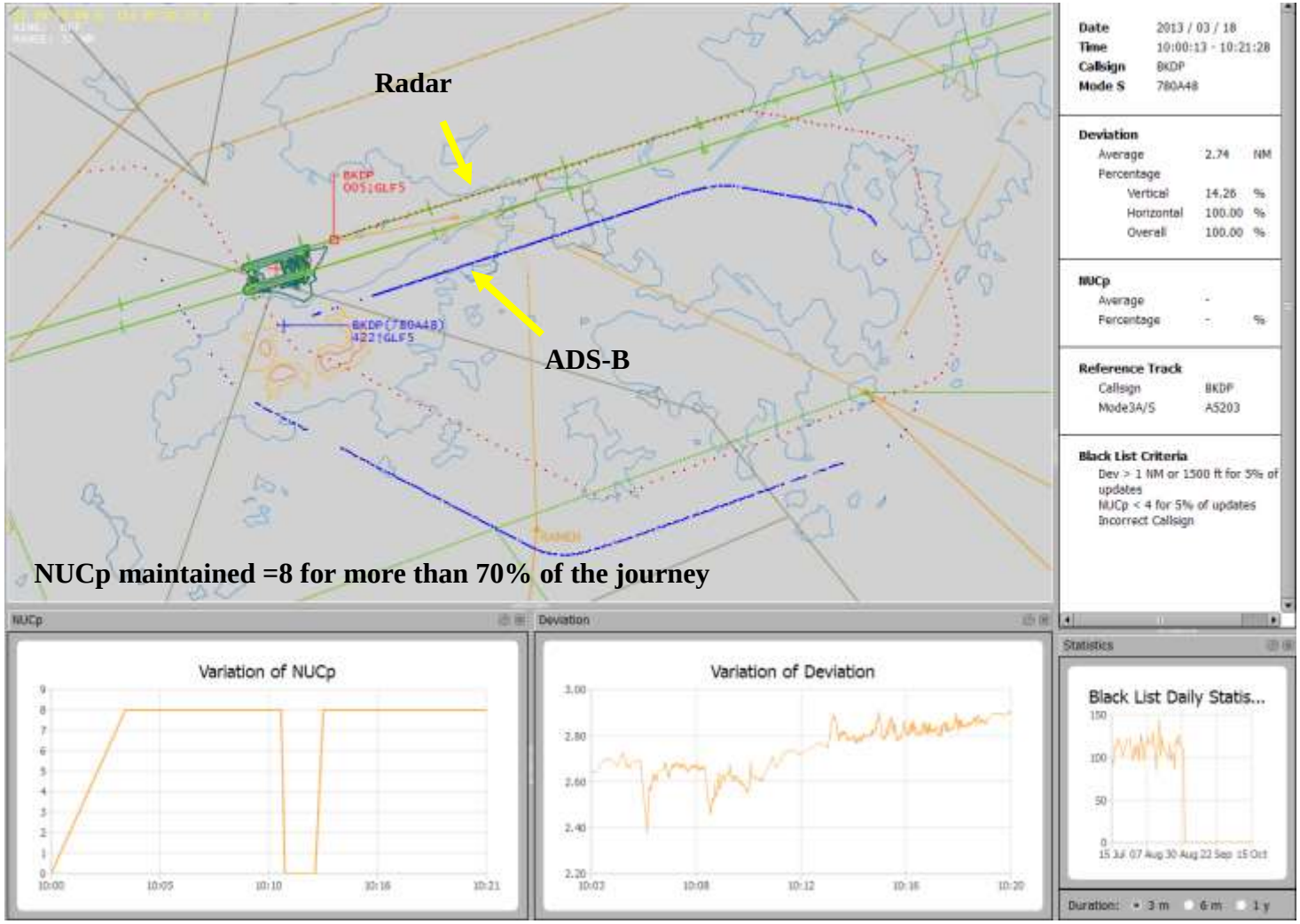
Appendix 3a

Average deviation from radar : 4.52NM



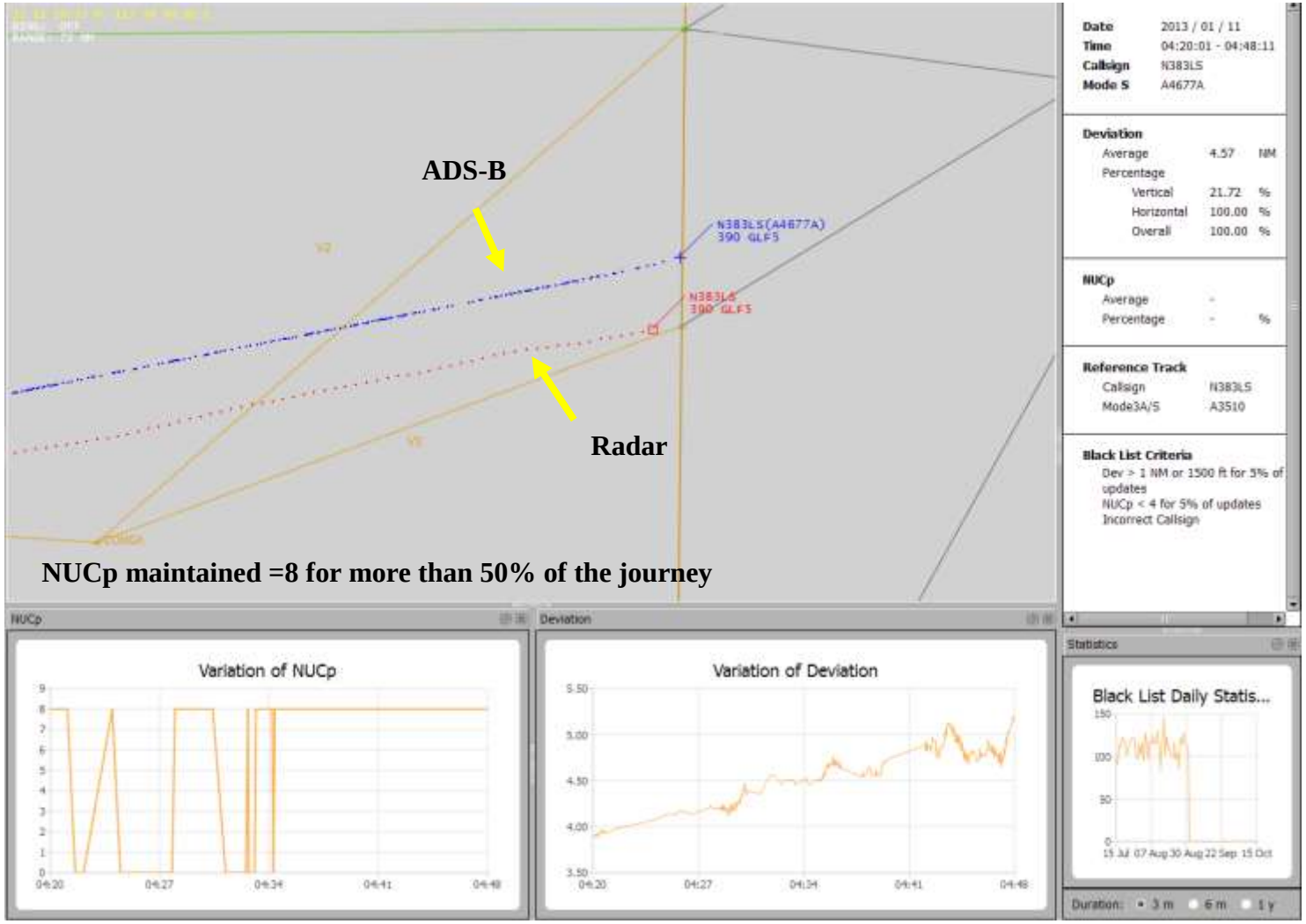
Appendix 3b

Average deviation from radar : 2.74NM



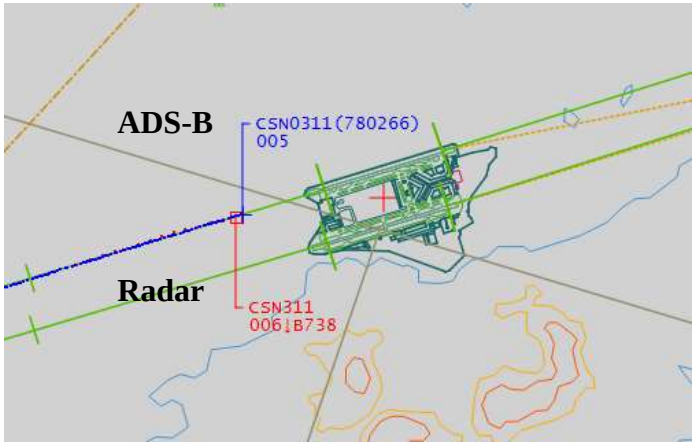
Appendix 3c

Average deviation from radar : 4.57NM

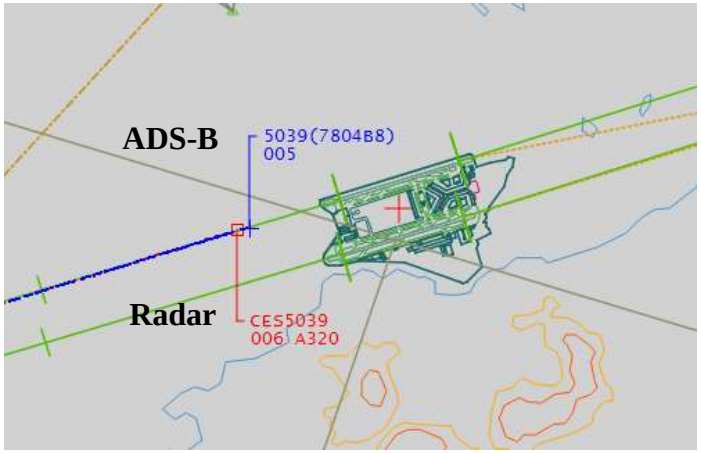


NUCp maintained =8 for more than 50% of the journey

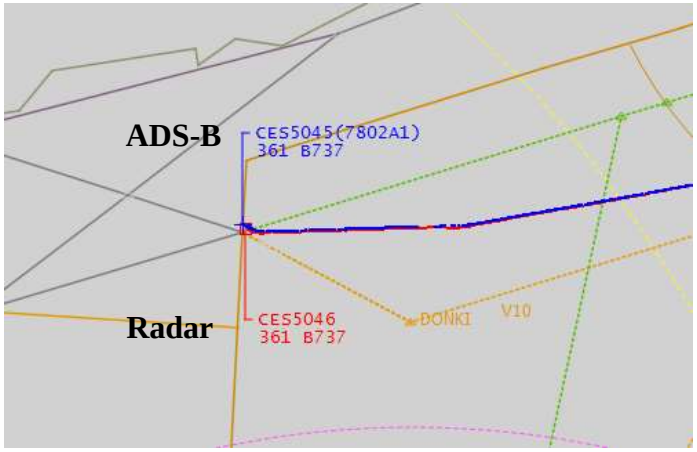
Appendix 4



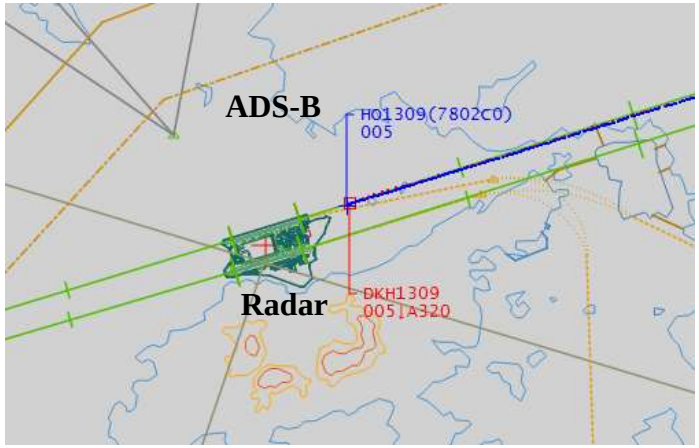
Additional zero inserted



ICAO Airline Designator Code dropped



Wrong numerical codes entered

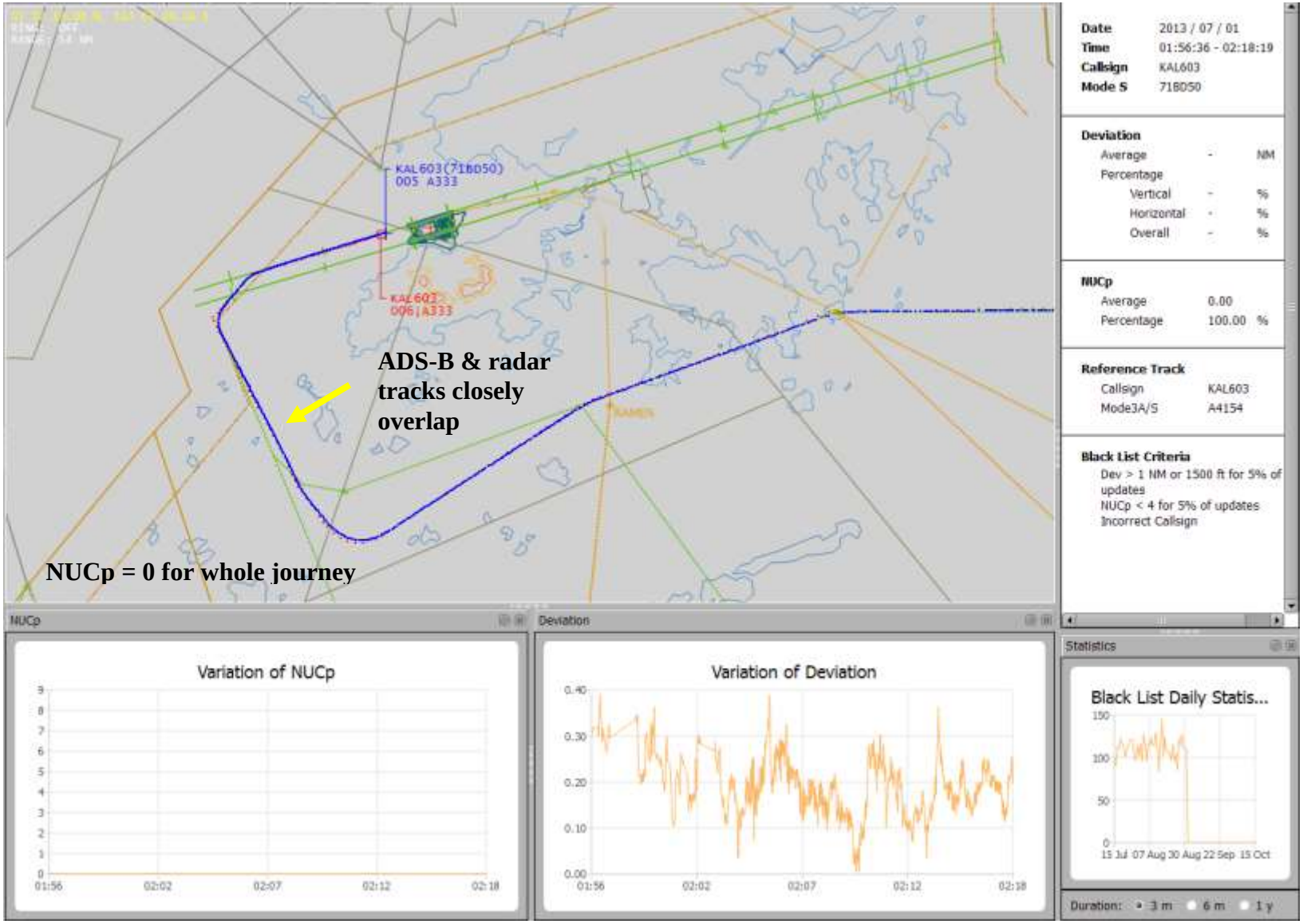


IATA Airline Designator Code used

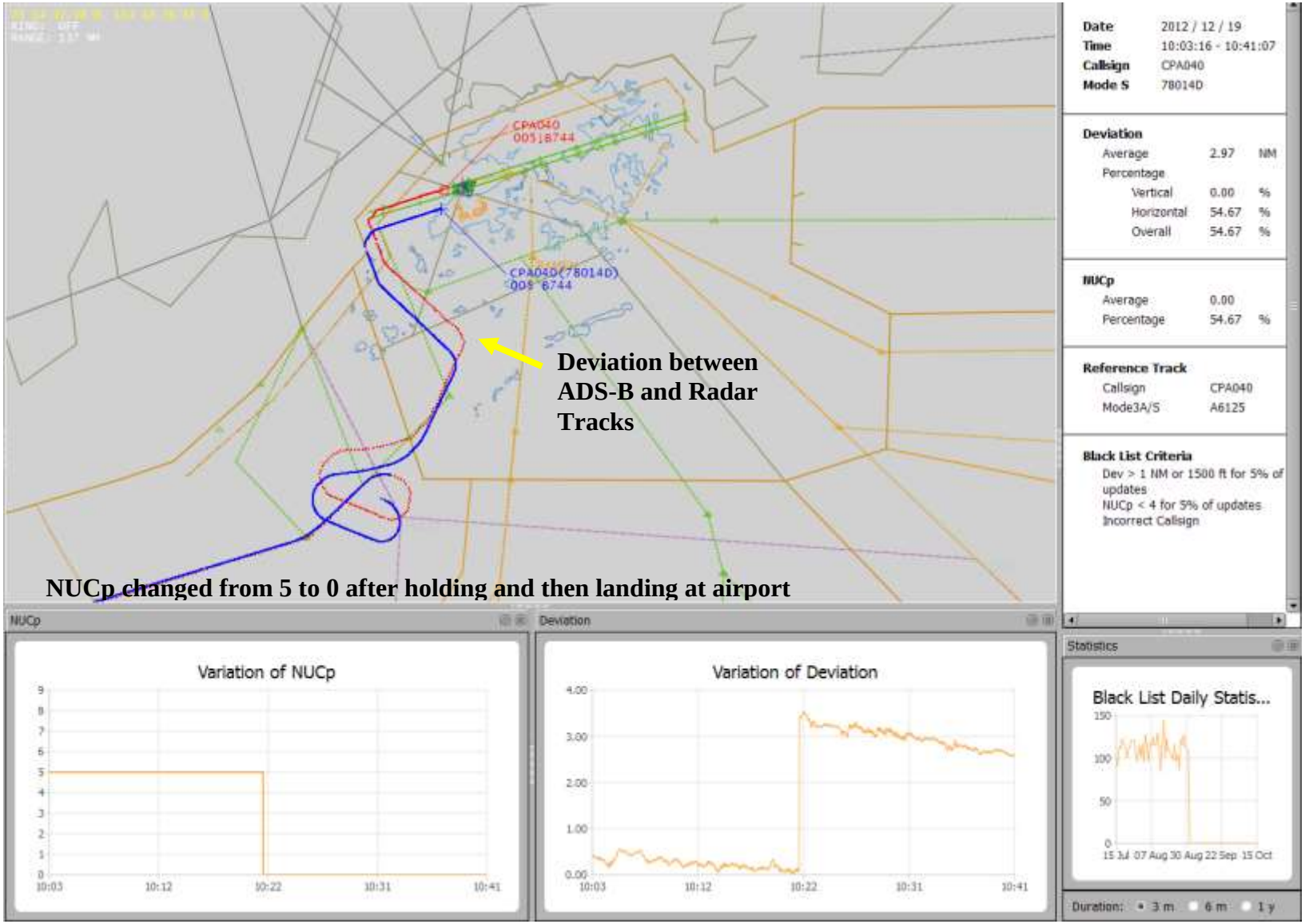
Appendix 5a


AHK129(7801C0)
005|A306
AHK129
006 A306
ADS-B & radar tracks closely overlap
NUCp = 0 for whole journey
Date 2013 / 08 / 31
Time 14:41:53 - 15:10:02
Callsign AHK129
Mode S 7801C0
Deviation
Average - NM
Percentage
Vertical - %
Horizontal - %
Overall - %
NUCp
Average 0.00
Percentage 100.00 %
Reference Track
Callsign AHK129
Mode3A/S A4167
Black List Criteria
Dev > 1 NM or 1500 ft for 5% of updates
NUCp < 4 for 5% of updates
Incorrect Callsign
NUCp
Variation of NUCp
Deviation
Variation of Deviation
Statistics
Black List Daily Statis...
Duration: 3 m 6 m 1 y

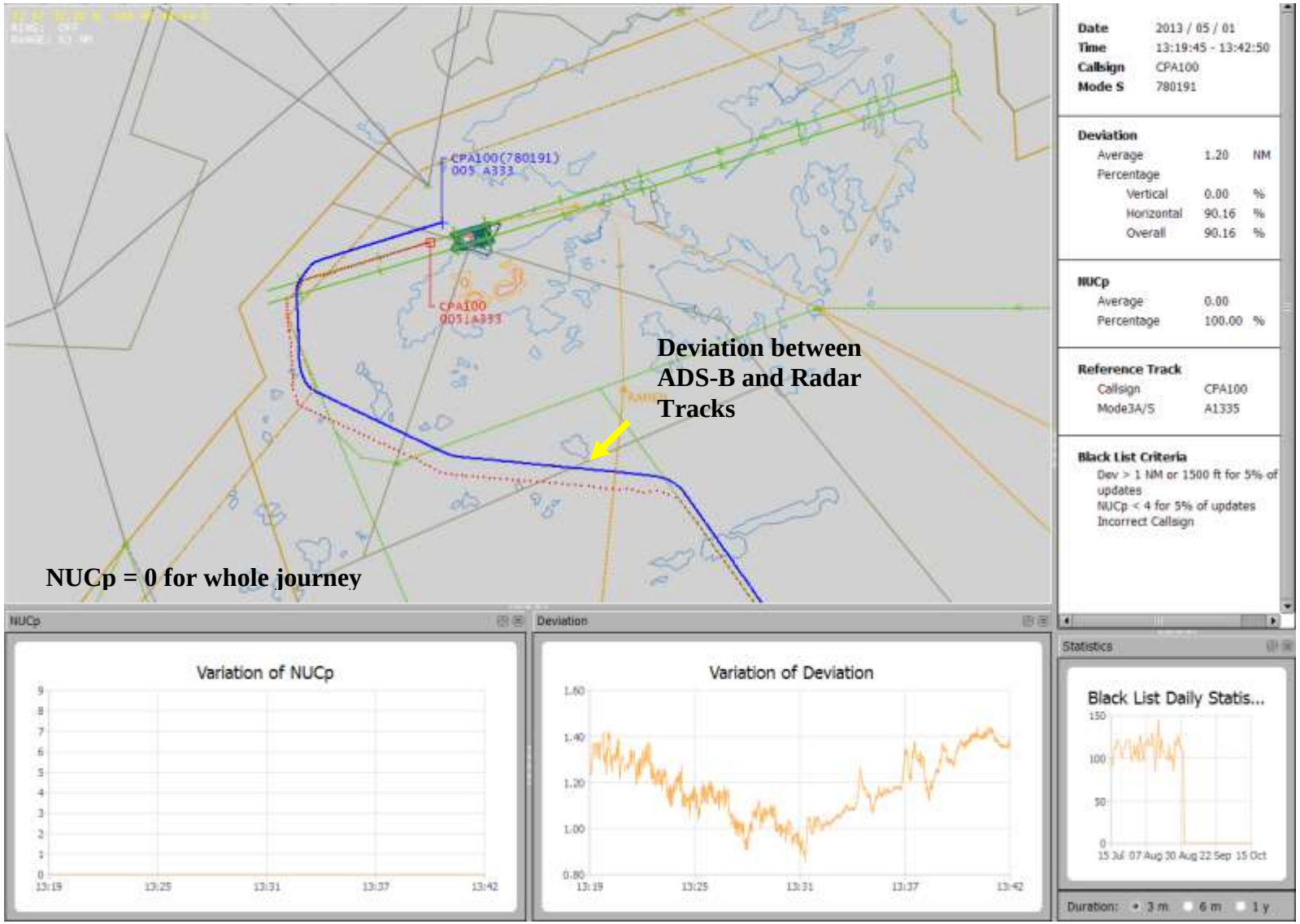
Appendix 5b


KAL603(718D50)
005 A333
KAL603
006 A333
ADS-B & radar tracks closely overlap
NUCp = 0 for whole journey
Date 2013 / 07 / 01
Time 01:56:36 - 02:18:19
Callsign KAL603
Mode S 718D50
Deviation
Average - NM
Percentage
Vertical - %
Horizontal - %
Overall - %
NUCp
Average 0.00
Percentage 100.00 %
Reference Track
Callsign KAL603
Mode3A/S A4154
Black List Criteria
Dev > 1 NM or 1500 ft for 5% of updates
NUCp < 4 for 5% of updates
Incorrect Callsign
NUCp
Variation of NUCp
Deviation
Variation of Deviation
Statistics
Black List Daily Statis...
Duration: 3 m 6 m 1 y

Appendix 5c


CPA040
00518744
CPA040(78014D)
005 6744
Deviation between ADS-B and Radar Tracks
NUCp changed from 5 to 0 after holding and then landing at airport
Date 2012 / 12 / 19
Time 10:03:16 - 10:41:07
Callsign CPA040
Mode S 78014D
Deviation
Average 2.97 NM
Percentage
Vertical 0.00 %
Horizontal 54.67 %
Overall 54.67 %
NUCp
Average 0.00
Percentage 54.67 %
Reference Track
Callsign CPA040
Mode3A/S A6125
Black List Criteria
Dev > 1 NM or 1500 ft for 5% of updates
NUCp < 4 for 5% of updates
Incorrect Callsign
NUCp
Variation of NUCp
Deviation
Variation of Deviation
Statistics
Black List Daily Statis...
Duration: 3 m 6 m 1 y

Appendix 5d


CPA100(780191)
005 A333
CPA100
005 A333
Deviation between ADS-B and Radar Tracks
NUCp = 0 for whole journey
Date 2013 / 05 / 01
Time 13:19:45 - 13:42:50
Callsign CPA100
Mode S 780191
Deviation
Average 1.20 NM
Percentage
Vertical 0.00 %
Horizontal 90.16 %
Overall 90.16 %
NUCp
Average 0.00
Percentage 100.00 %
Reference Track
Callsign CPA100
Mode3A/S A1335
Black List Criteria
Dev > 1 NM or 1500 ft for 5% of updates
NUCp < 4 for 5% of updates
Incorrect Callsign
NUCp
Variation of NUCp
Deviation
Variation of Deviation
Statistics
Black List Daily Statis...
Duration: 3 m 6 m 1 y