International Civil Aviation Organization

AUTOMATIC DEPENDENT SURVEILLANCE – BROADCAST SEMINAR AND TWELFTH MEETING OF AUTOMATIC DEPENDENT SURVEILLANCE – BROADCAST (ADS-B) STUDY AND IMPLEMENTATION TASK FORCE (ADS-B SITF/12)

Kolkata, India, 15-18 April 2013

Agenda Item 5: **ADS-B performance monitoring**

ASSESSMENT OF ADS-B PERFORMANCE TO SUPPORT ATS IN INDIA

(Presented by Airports Authority of India)

SUMMARY

This paper provides an insight into the assessment undertaken by India to compare the accuracy of horizontal position of ADS-B track with RADAR track. This assessment was done to complement the Separation and Airspace Safety Panel (SASP) assessment with ADS-B local implementation-focused assessment and address specific local implementation requirements. This paper also explains the assessment methodology and recommends States/Administrations to duly consider conducting a local assessment before using ADS-B surveillance for air traffic services to provide radar-like services.

1. Introduction

1.1 The ICAO Review of the General Concept of Separation Panel (RGCSP), now SASP after undertaking a Global assessment of ADS-B technology has concluded that ADS-B as a technology can be used as a means of supporting the provision of a five nautical mile (5 NM) separation minimum between an aircraft pair like that of a radar and the minima are already published in ICAO Doc 4444, PANS-ATM to that effect. However ICAO circular 311 recommends a local implementation assessment as a supporting activity for a State assessment and focus specifically on ADS-B implementation issues such as hazard identification.

1.2 Airports Authority of India has installed 14 ADS-B ground stations in various Airports in India and it is proposed to integrate ADS-B data with ATM automation systems and used in the provision of Air Traffic Services. An assessment was undertaken on the use of ADS-B surveillance by the air traffic services to provide radar-like services.

2. Discussion

2.1 The ICAO Separation and Airspace Safety Panel (SASP) undertook an assessment of the use of ADS-B to support air traffic services. The basis of assessment was a comparison of ADS-B to reference secondary surveillance radar (SSR).

2.2 India undertook a similar assessment to compare the accuracy of horizontal position of available ADS-B track with RADAR system track. ADS-B data of those aircraft that used a mode S transponder to reply to both radar interrogations and to transmit ADS-B messages received from two ADS-B ground receivers one at Chennai and another at Trivandrum were taken for this assessment. Since the same airborne transmitter and airborne antenna was used for both ADS-B and radar signals, the comparison could be made interms of accuracy of horizontal position of the two tracks with minimum difference due to other variables. This was based on the accepted ICAO assumption that only accuracy and integrity of horizontal position are of concern and not the Vertical position as Barometric altitude information is equivalent to Mode C.

2.3 During the assessment the ADS-B data received by ground stations at Chennai and Trivandrum were fed into the Alternate (Simulator) string of the (ATM) automation System in live OPS mode without input from any of the available MSSR. RADAR system track were recorded in the Operational (Main) String of the ATM system. Thus the ADS-B Track Data and system Track Data of these aircraft created by the Alt string SDP & main string SDP simultaneously are archived in the respective FDP of alternate/main string. The archived ADS-B Track Data and the RADAR system Track Data are retrieved separately in standard Asterix CAT 062 format using the Data Reduction and Presentation (DRAP) report generation tool from the respective FDPs.

2.4 The Terminal Area Route Generation, Evaluation and Traffic Simulation (TARGETS) software of MITRE Corporation of USA was used for traffic simulation and compare the data. The system has rich functionality and designed with a Graphical User Interface (GUI) which is intuitive. Standard Asterix CAT 062 Track data messages of aircraft generated by automation systems can be imported into the system. Simulations can be built using the imported track data and can be run in real time, using the default 4.7 second update rate of terminal radar.

2.5 Thus a simulation report can be generated for analyzing the accuracy of positional information of the track at different timings. Simulations and track data can be exported in the PDARS format which is a CSV format that can be viewed in any spreadsheet program and can be compared.(Detail report attached as Appendix 1 to this WP)

3. Action by the Meeting

3.1 The meeting is invited to:

a) distinguish between assessments undertaken by States for purposes of implementation at local or regional level and undertaken by SASP from a global perspective;

b) recognize the need for conducting regional/local assessment to complement SASP assessment;

c) take note of the supporting activity required for an ADS-B implementation safety assessment;

d) recommend States/Administrations to carry out a comparison of ADS-B to a reference secondary surveillance radar (SSR);

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Appendix-1

1. ASSESSMENT OF ADS-B SURVEILLANCE

1.1. Introduction

This chapter presents the comparative assessment of ADS-B surveillance for use by the air traffic services. The assessment methodology is explained below, as is the rationale behind its use and the conclusions drawn from it. It has been agreed that if ADS-B can be demonstrated to be as good as radar in the relevant system performance measures, then it can be used to deliver the services that radar currently supports.

1.2. Scope

The Scope of this assessment includes collection of ADS-B and MSSR only radar data within the airspace of India for the comparative assessment of ADS-B surveillance data with that of Radar. As a minimum this includes collection of data related to the airspace of at least two Terminal Control Areas, namely Chennai and Trivandrum.

The study's scope also considers AAI's responsibilities in adopting a proactive approach to assess the Indian airspace in terms of available surveillance coverage, and to pursue the objective of achieving seamless surveillance over the entire Indian airspace, including the Oceanic airspace of Bay of Bengal and Arabian Sea.

1.3. Objectives of the assessment

The general objective of this assessment is to demonstrate that ADS-B surveillance can be used to provide a 5 NM separation minimum in an ADS-B only environment or an ADS-B/radar environment.

1.4. Assessment methodology

1.4.1. Analysis was performed using aircraft that used a mode S transponder to reply to both radar interrogations and to transmit ADS-B messages.
Data was analyzed to compare radar and ADS-B data. The results of the data analysis for a number of flights are presented in this report. The details provided are typical of the data collected for the aircraft operating in the Indian airspace, and as such is considered representative of the system's performance.

1.4.2. The comparison was performed by analyzing data (RADAR system track recorded by the Operational String of the ATM system and ADS-B track recorded by the Alternate string of ATM system) to determine the difference between the two. The Terminal Area Route Generation, Evaluation and Traffic Simulation (TARGETS) software produced by the MITRE Corporation and CSSI of USA was used for traffic simulation and comparison of the data.

1.5. Application of assessment methodology

1.5.1. The Raytheon Air Traffic Management (ATM) automation System has two partitions, the main for operational use and the alternate partition for training. The automation system has the capability to enable live operational use of the Alternate (Alt) partition from simulator mode without affecting the main partition.

1.5.2. During the assessment the ADS-B data for specific aircraft received by ground stations at Chennai and Trivandrum were input into the Alternate (Simulator) string of the Raytheon Air Traffic Management (ATM) automation System AT3+ in live OPS mode without input from any of the available MSSR. The data were processed by the AT3+ system and displayed in the Controller workstations available in the simulator room.

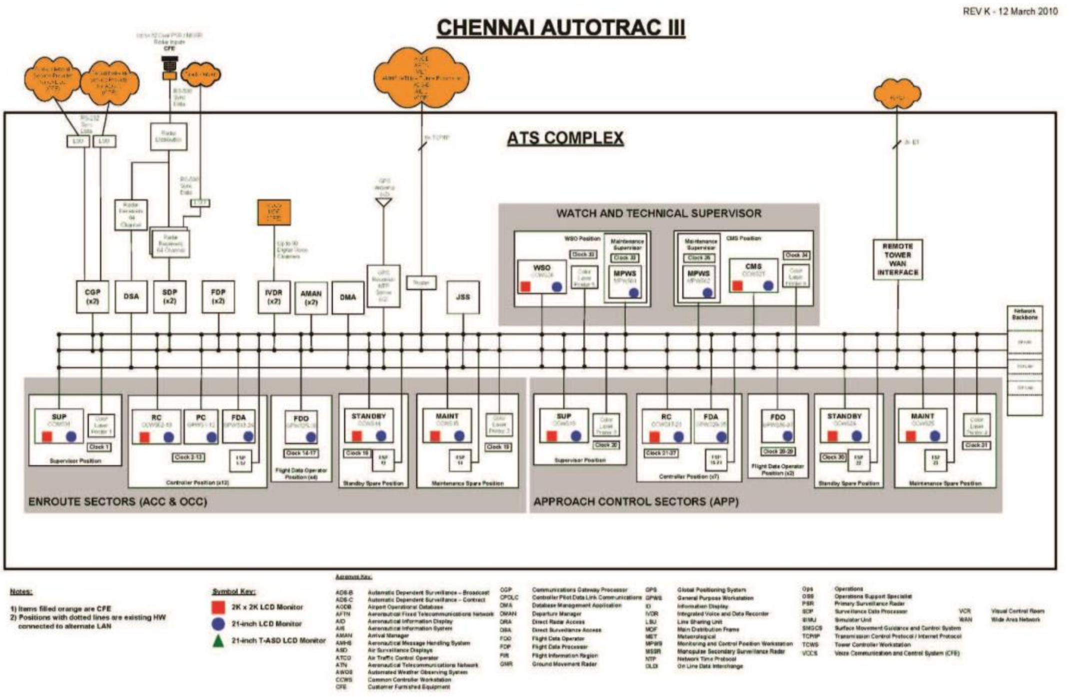
1.5.3. The above mentioned aircraft while transmitting ADS-B messages on the extended squitter of the Mode S transponder also replied to radar interrogations of the MSSRs which are integrated with AT3+ system when flying within the coverage areas of these RADARs. The fused RADAR Tracks were then displayed as a System Track in the Controller workstations available in the ACC (main string).

1.5.4. The ADS-B Track Data created by the Alt string SDP are normally archived in the Flight Data Processor (FDP) of AT3+ alternate string and the system Track Data for the same aircraft created by the main string Surveillance Data Processor (SDP) are archived in the FDP of main string.

1.5.5. For the purpose of the assessment, the archived ADS-B Track Data and the RADAR system Track Data were retrieved separately in standard Asterix CAT 062 format using the AT3+ Data Reduction and Presentation (DRAP) report generation tool from the respective FDPs.

1.5.6. A block diagram of the AT3+ system architecture used in the assessment is presented in Figure6.

Figure6: AT3+ System Architecture



1.6. TARGETS Software

Terminal Area Route Generation, Evaluation and Traffic Simulation (TARGETS) is a software, that is rich in functionality and designed with a Graphical User Interface (GUI) that is intuitive. Standard Asterix CAT 062 Track data messages of aircraft generated by automation systems can be imported into the system and the imported tracks are displayed in the current View, and the track set is added to the Track Data folder within the Project and View browser folders.

Simulations can be built using the imported track data and the simulation profile for traffic produced by a generator is displayed in the Plan View. The Track sets in the plan view can be exported as images.

Simulations can be run in real time, using the default 4.7 second update rate of terminal radar. The system can work with large track data sets, multiple image files, and complex simulations. Simulated traffic is displayed in the TARGETS Plan View.

A simulation report can be generated for analyzing the positional information of the track at different timings. Simulations and track data can be exported in the PDARS format which is a CSV format that can be viewed in any spreadsheet program and can be compared.

1.7. Data Collection

1.7.1. Two sets of data were collected, one from the airspace of Chennai TMA and the other from the airspace of Trivandrum TMA. The ADS-B and Radar data of two flights IGO431 & SEJ282 flying within Chennai TMA on 9th September 2012, was collected from the ATM Automation system at Chennai. The ADS-B data for two flights ABY0506 & ALK266 which used Trivandrum airspace, on 18th February 2013, was collected from COMSOFT ADS-B ground station at Trivandrum and the radar data for the same, from Chennai ATM automation. Table1 presents the details of the four flights.

Date	Call Sign	Type of Aircraft	Departure Aerodrome	Destination Aerodrome	Remarks
09.09.2012	IGO431	A320	Mumbai	Chennai	Landing Phase
	SEJ282	B738	Coimbatore	Chennai	Landing Phase
18.02.2013	ABY0506	A320	Colombo	Sharjah	Climbing Phase
	ALK266	A343	Riyadh	Colombo	Cruising Phase

Table1. Details of aircraft used for the assessment

1.7.2. The details of the archived Asterix CAT 062ADS-B and RADAR system Track Data Reduction and Presentation (DRAP) reports generated in the AT3+ Alternate and Main string on 9th September 2012 & 18th February 2013 in Chennai ATM automation system for the assessment are given in Table2.

S.NO	DATE	TIME IN UTC		NO OF MESSAGES*	
		FROM	TO	ADS-B (ALT)	RADAR SYSTEM TRACKS (MAIN)
1	09/09/2012	0600	0630	3966	134824
2	18/02/2013	2030	2359	25735	131750

Table2. Details of archived ADS-B and Radar messages

1.8. Data Analysis

The data was analyzed to compare the ADS-B & radar track positions and determine the difference between the two. A comparison of radar and ADS-B altitude data was also undertaken which showed that though the source of barometric altitude, the altitude encoder, is the same for ADS-B and radar, a small difference does occur which is due to the fact that ADS-B data is consistently updated at a higher rate compared to radar. During an aircraft's climb or descent the radar derived altitude tends to lag the ADS-B reported altitude. Hence during climb or descent phase a small difference in the altitude is seen which reduces when aircraft reaches the cruising level.

1.8.1. Display of Radar and ADS-B tracks.

Figure 7 shows the traffic scenario depicted in plan position on the Chennai Approach Radar Controller's display on 9th September 2012. Both Radar and ADS-B tracks are displayed for IGO431 and SEJ282. The radar track is in … with a … color data block and the ADS-B track is shown in …. with a…. color data block. Both the flights are following the Standard Arrival Routes for landing on Runway 25.

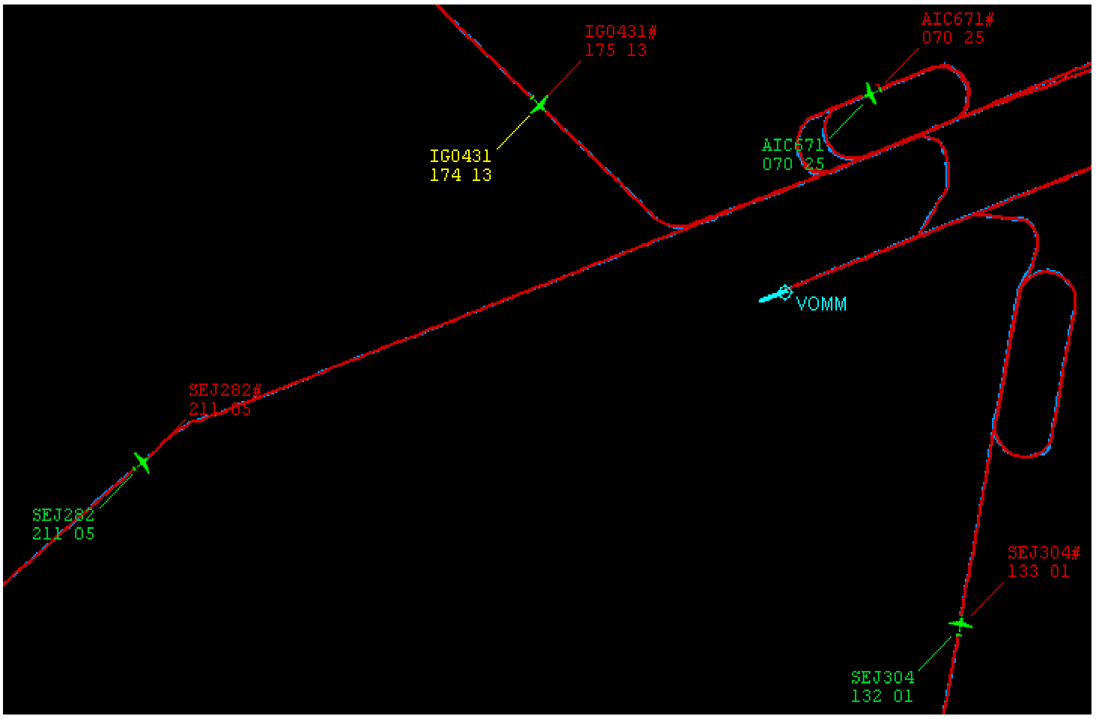


Figure7. Radar and ADS-B track display

Figure 8 below is a blow up picture taken of the display showing the radar and ADS-B tracks of IGO431. The smallest display range was selected to highlight the difference between the two tracks. The picture shows a difference of 0.14NM between the two track positions at a specified time.

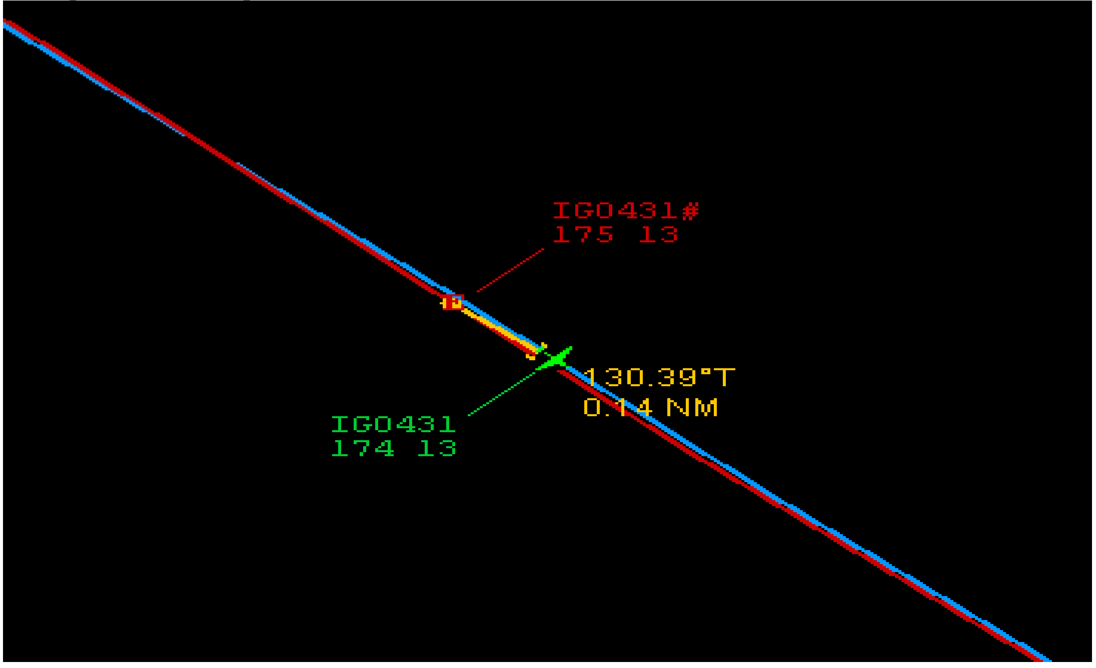


Figure 8 Radar and ADS-B track display

1.8.2. Comparison of radar and ADS-B track position:

Figure 9 below, shows the radar and ADS-B tracks for IGO431 an A320, operated by Indigo airlines on a flight from Mumbai to Chennai on 9th September 2012 which had commenced its descent on the Standard Arrival Route (STAR) for landing on RWY25 at Chennai.

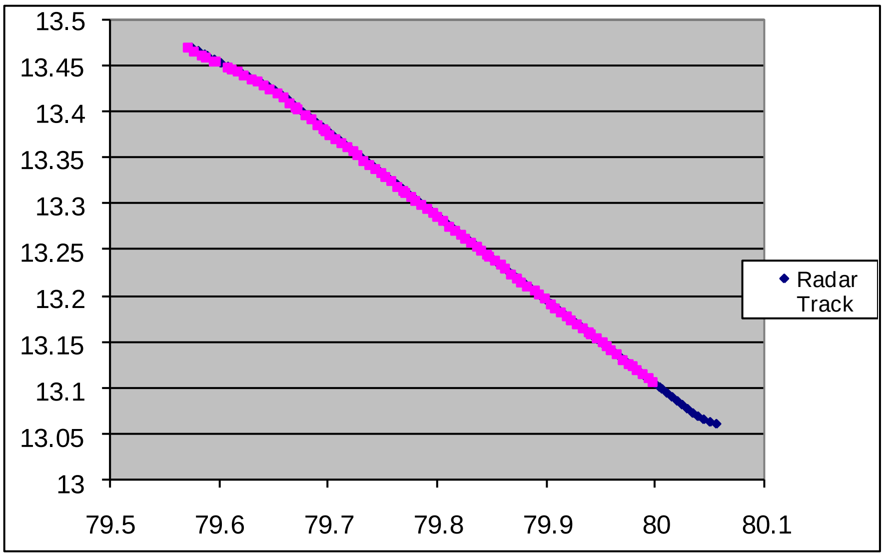


Figure9. Comparison of ADS-B and Radar tracks of IGO431

Figure 10 shows the radar and ADS-B tracks for SEJ 282, a Spice jet operated B738, from Coimbatore to Chennai. The flight was tracked as it descended into Chennai.

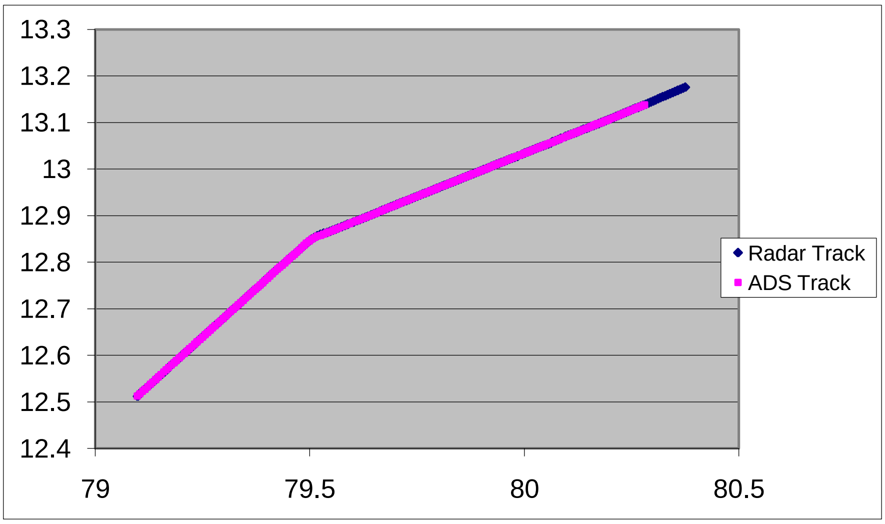


Figure10. Comparison of ADS-B and Radar tracks of SEJ282

Figure 11 and Figure 12 below show the plot of the difference in position between the radar and ADS-B reports for IGO431 & SEJ282 respectively. The ADS-B and radar positions are shown to be generally within 0.5NM of each other.

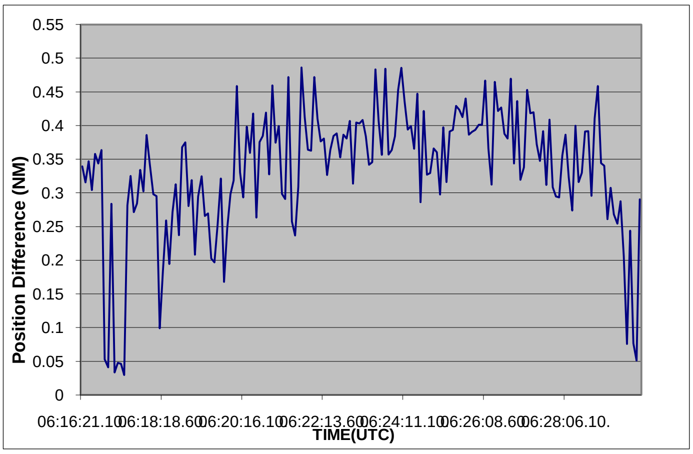


Figure11. Difference between ADS-B and Radar position reports of IGO431

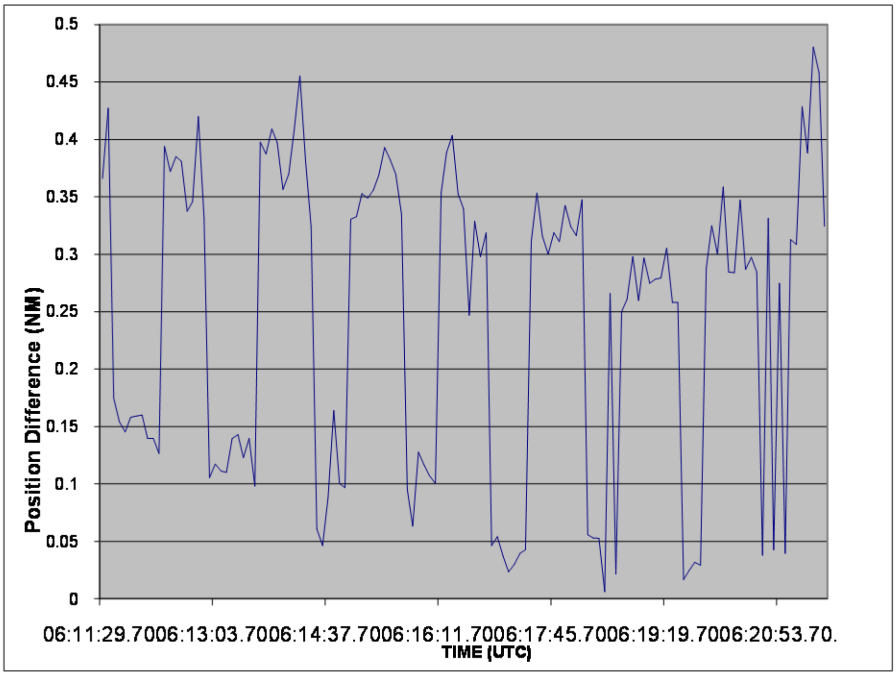


Figure12. Difference between ADS-B and Radar position reports of SEJ282

Figure 13 presents a comparison of the displayed barometric altitude based on radar and ADS-B data during the flight of SEJ282 on 9th September 2012.

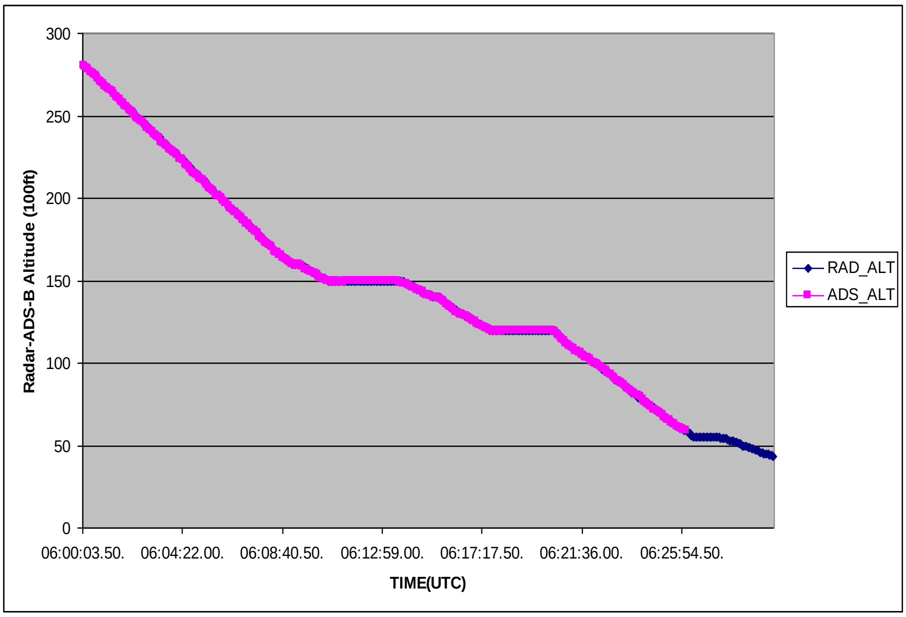


Figure13. Comparison of ADS-B and Radar derived Barometric altitude of SEJ282

The difference between the displayed radar and ADS-B altitude during the same flight is graphed in Figure 14.It has been observed that the difference in the altitude is between +/- 100 Feet most of the time. It should be noted that Mode C does not provide any error detection capability, making false readings a relatively frequent occurrence. ADS-B altitude data, on the other hand, is subjected to a rigorous error detection and correction process greatly reducing the probability of erroneous altitude reports being presented to the controller.

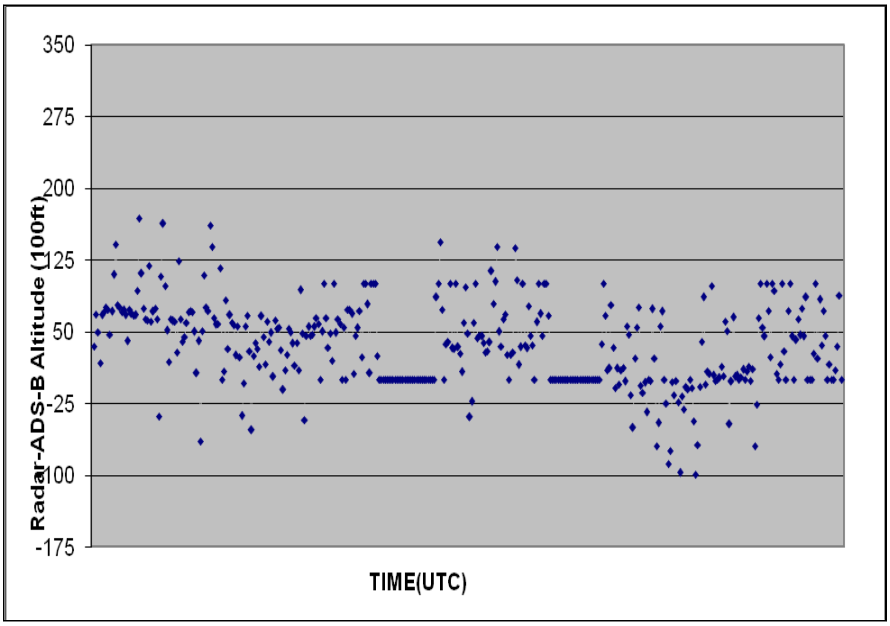


Figure14. Difference between ADS-B & radar derived barometric altitude of SEJ282

A similar exercise of determining, the difference between the ADS-B & Radar track positions and the difference between radar & ADS-B derived barometric altitude was conducted using data of two flights, ABY0506 & ALK266 collected from the Trivandrum ADS-B ground station and the Trivandrum radar.

Figure 15 shows the ADS-B and radar track positions of ABY0506 an A320 flight of Air Arabia that had departed Colombo for Sharjah and entered the airspace of Trivandrum TMA in the climbing phase, climbing to FL360.

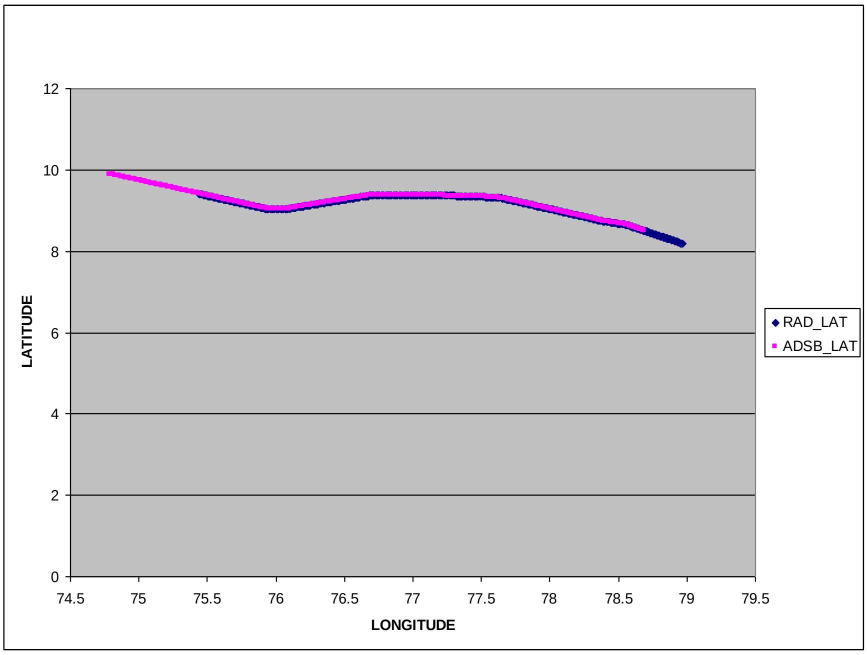


Figure15. Comparison of ADS-B and Radar tracks of ABY0506

The ADS-B and radar track positions of ALK266 an A343 operated by Air Lanka from Riyadh to Colombo is shown in Figure16. The flight was tracked in the cruising phase during its transit through the Trivandrum TMA.

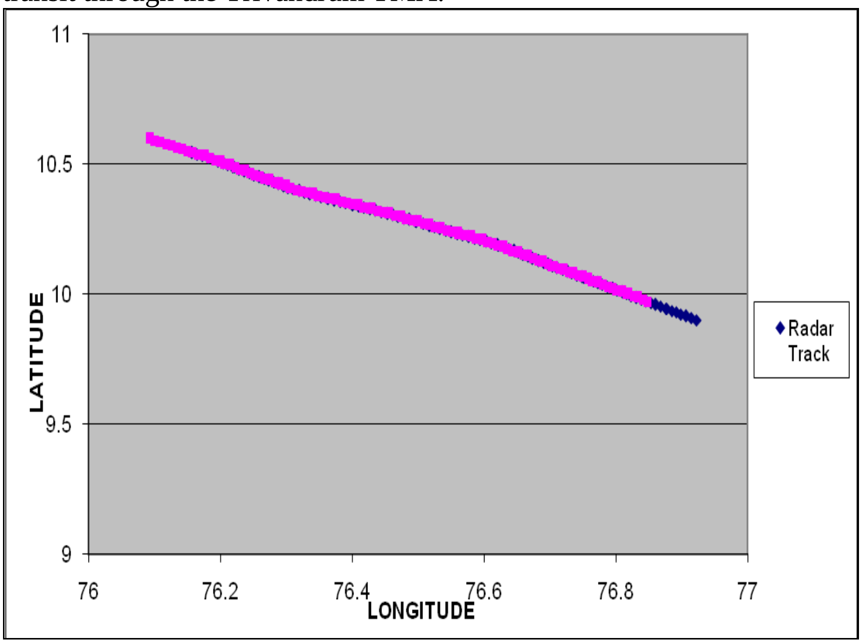


Figure16. Comparison of ADS-B and Radar tracks of ALK266

Figure17 and Figure18 below show the plot of the difference in position between the radar and ADS-B reports for ABY0506 & ALK266 respectively.

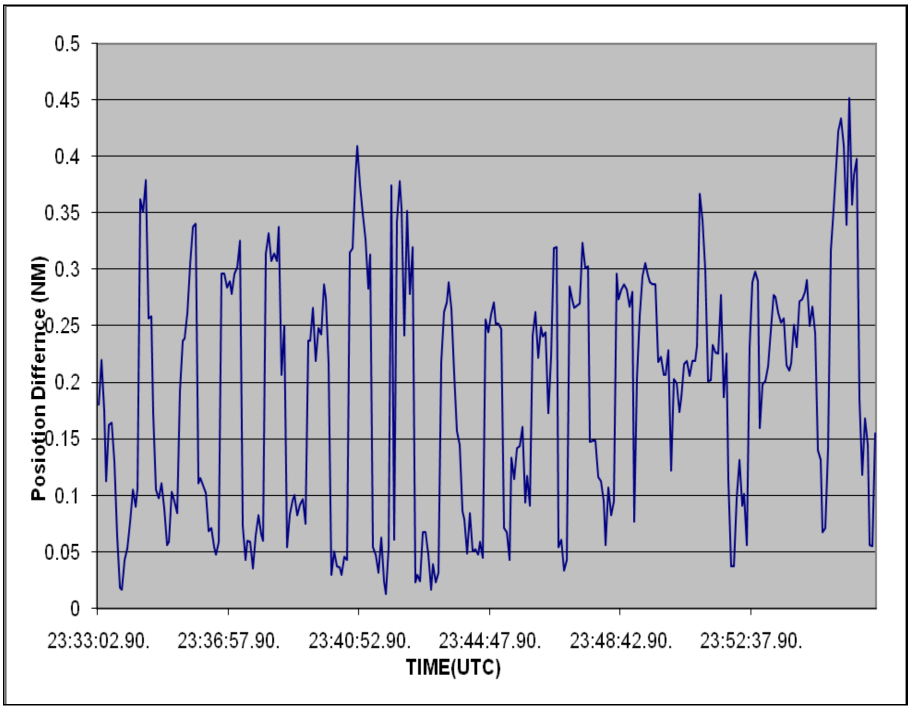


Figure17. Difference between ADS-B and Radar position reports of ABY0506

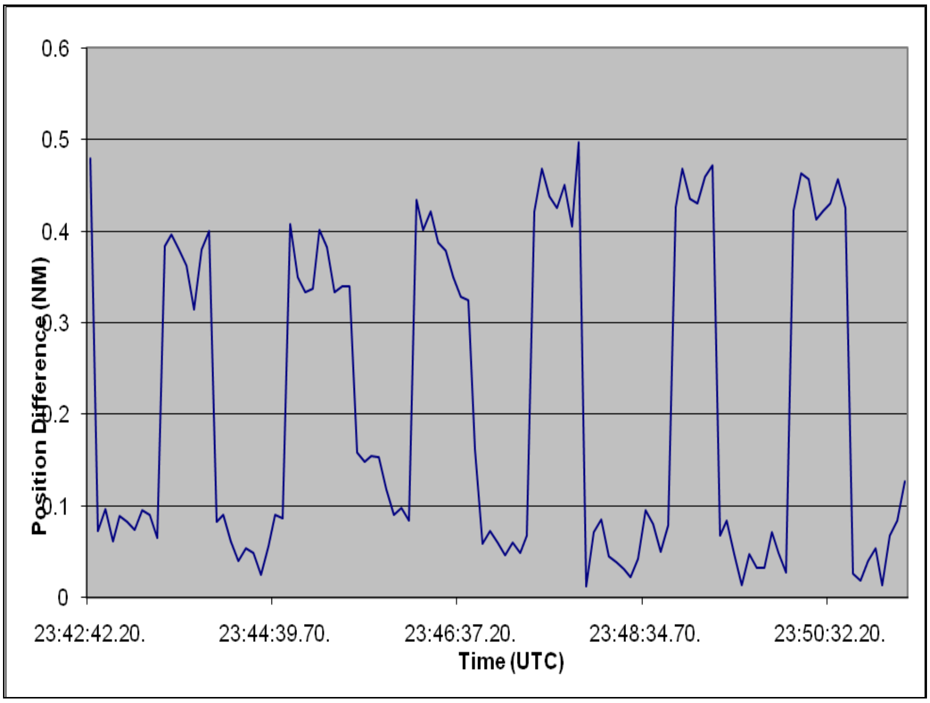


Figure18. Difference between ADS-B and Radar position reports of ALK266

Figure19 and Figure20 presents a comparison of the displayed barometric altitude based on radar and ADS-B data of ABY0506 * ALK266 respectively.

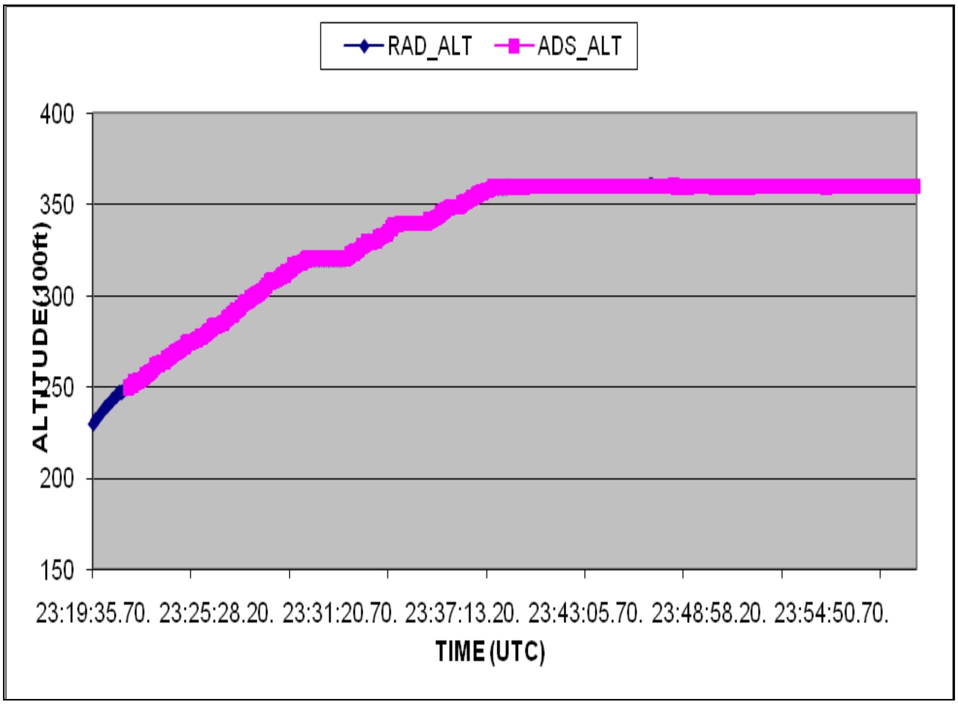


Figure19. Comparison of ADS-B and Radar derived barometric altitude of ABY0506

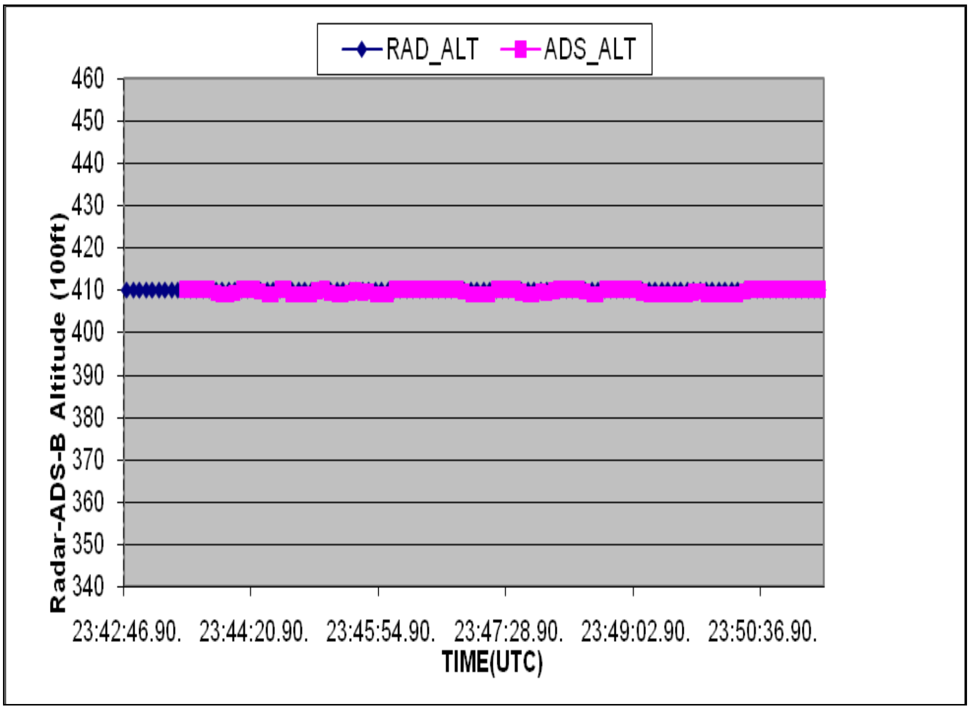


Figure20. Comparison of ADS-B and Radar derived barometric altitude of ALK266

Figure 21 and Figure22 shows the difference between the displayed ADS-B and Radar derived barometric altitude of ABY0506 & ALK266 respectively. It is seen that in the case of ABY0506 which was on a climbing phase after departure the difference is significant than in the case of ALK266 which was monitored in level flight. Still there is close agreement between the two altitudes, with the difference being within +/- 100 feet for more than 95% of the time in both the case.

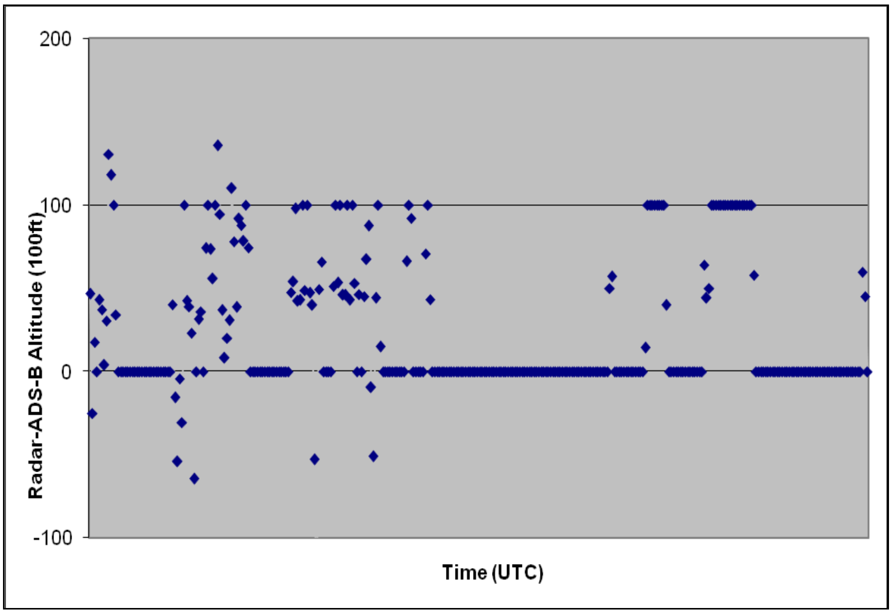


Figure21. Difference between ADS-B & Radar derived barometric altitude-ABY0506

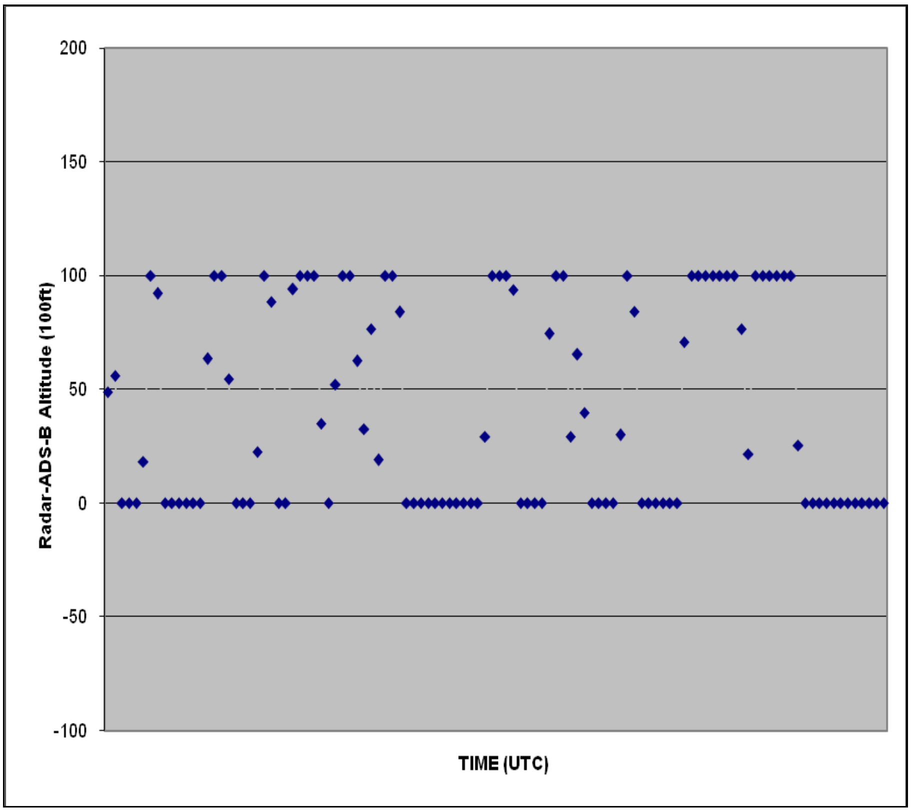


Figure22. Difference between ADS-B & Radar derived barometric altitude - ALK266

1.9. ADS-B Coverage

The predicted line of sight coverage based on terrain data maps of ADS-B ground station installed at Trivandrum is given in Figure23. Factors that can affect coverage are receiver sensitivity and secondary surveillance radar (SSR) RF density. In high density regions the probability of detection may be reduced as a result of garbling or the overlapping of replies at the receiver.

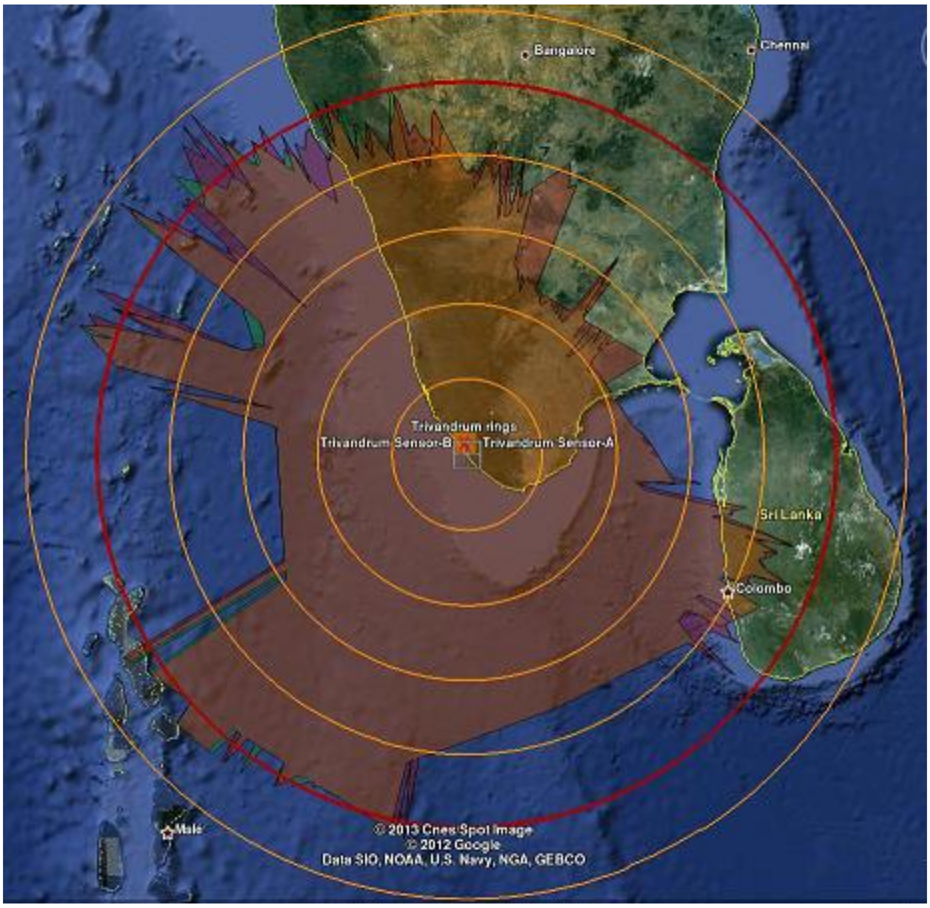


Figure23. Trivandrum ADS-B Coverage

2. CONCLUSION

In general there is a demonstrated close agreement between the data displayed to controllers from both radar and ADS-B. The ADS-B tracking performance appears to be better or at least no worse than the reference MSSR.

As such, ADS-B surveillance can be used to provide 5 NM separation minima for either en route or terminal area operations whether ADS-B is the sole means of ATC surveillance or used together with radar.

Nevertheless, there is a requirement to undertake an implementation safety assessment that demonstrates that the intended safety level will be met using ADS-B surveillance.

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