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Navigation Applications of Space Based ADS-B Information

Dirk-Roger Schmitt[a]*, Frank Morlang[a], Simone Moser[b], Sven Kaltenhäuser[a]

[a] *Deutsches Zentrum für Luft und Raumfahrt e.V. (German Aerospace Center, DLR), Lilienthalplatz 7, 38108 Braunschweig, Germany*, dirk-roger.schmitt@dlr.de
[b] *OHB Luxpace, 9, rue Pierre Werner, 6832 Betzdorf, Luxembourg*

Abstract

The Automatic Dependent Surveillance-Broadcast (ADS-B) is seen as an important technology to improve Air Traffic Surveillance (ATS) and Air Traffic Control (ATC) capabilities. Today, ADS-B is an established technology, globally and widely used in continental airspace. Since 2008 the German Aerospace Center (DLR) started to prove that 1090ES ADS-B signals broadcasted by aircraft can be received on board of low earth orbiting (LEO) satellites. This was validated in 2013 by world's first in-orbit demonstration of a space-based ADS-B system, hosted on the ESA satellite PROBA-V. The introduction of space-based ADS-B opens new opportunities, e.g. by complementing and enhancing the existing terrestrial ADS-B. Today, several commercial service providers are operating LEO constellations and offering the service of their received ADS-B data. Several new constellations are planned. In this context new services to use the space-based data and to fuse them with other data from ground based surveillance systems are being discussed. So-space based ADS-B data can be fused with ground based ADS-B and radar surveillance data to obtain a higher level of situational awareness in the airspace. This is of increasing interest in the vicinity of airports where still some surveillance lacks might exist which can be filled-up by space data.

Keywords: ADS-B, PROBA-V, Commercial Space, Spaceflight, Airports, Air Traffic Management, SWIM

1. Introduction

The existing data of the PROBA-V mission have been analyzed with respect to their applicability near to airports in numerous papers [1, 2]. It could be shown, that especially in some regions of mid-size airports the surveillance information can be significantly enhanced by use of space based ADS-B data. Further, integration of the data to the information exchange concept of the System Wide Information Management (SWIM) of the Single European Sky (SESAR) and the US NextGen is discussed. A SWIM interface was developed and tested. The results show, that fused ADS-B based surveillance data can be exchanged easily on a global scale via standardized SWIM services. Today there is the option to fuse space based ADS-B data with ground based ADS-B and radar surveillance data to obtain a higher level of situational awareness in the airspace. This can yield to improvements for situational awareness at airports.

2. ADS-B

ADS-B implemented in modern Mode-S transponders on board aircraft transmits periodically the flight position and other information by Extended Squitter messages (1090ES) on the 1090 MHz SSR-Mode-S downlink frequency (ADS-B Out). Another data link technology providing ADS-B is Universal Access Transceiver (UAT), which is operating at 978 MHz, but which is used within the US NAS only. The European ADS-B Mandate requires that all aircraft heavier than 5700 kg or faster than 250 knots have to be equipped with ADS-B-Out from 2020 on. In 2020 ADS-B surveillance shall become fully operational. Similar regulations exist for some Asian regions and the U.S., whilst in Australia ADS-B-Out was required from end of 2012 on. On the other hand most regions of the world are uncontrolled airspace, since in oceanic, polar or mountainous regions or underdeveloped continental areas the installation of ground based surveillance systems is either technically or economically impossible. In these so-called Non-Radar Airspaces (NRA) surveillance is applied procedurally, which means that the pilot issues position reports via aircraft radio when certain waypoints have been reached. Modern aircraft are also equipped with ADS-C (Automatic Dependent Surveillance–Contract), a point-to-point data link connection based on FANS1/A equipment and Satcom or HFDL data link. Due to limited bandwidth and service costs the system transmits the flight position and other information only every 15 minutes. In both cases no seamless and continuous flight surveillance is possible, with the consequence of separation distances of 50 – 80 NM due to safety reasons. [3, 4]

As ADS-B receiving ground stations are less complex and costly than radar stations, they will complement or even replace radar stations in the future, being integrated in the existing surveillance infrastructure.

3. Satellite based ADS-B

Since 2008 the German Aerospace Center (DLR) started to prove that 1090ES ADS-B signals broadcasted by aircraft can be received on board of low earth orbiting (LEO) satellites. This was validated in 2013 by world's first in-orbit demonstration (IOD) of a space based ADS-B system, hosted on the ESA satellite PROBA-V [1, 2].

Fig. 1. Proba-V-Satellite. Source: www.esa.int

The experiment was conducted in the frame of ESA's PROBA-V mission (PROBA Vegetation) and was successfully launched by Europe's newest launcher VEGA on 7th of May 2013 at 04:06:31 CEST from the European spaceport Centre Spatial Guyanese (CSG) in French Guyana.

The IOD is capable to receive, decode and forward all Mode S downlink telegram formats. This includes the DF17 Extended Squitter comprising ADS-B information and DF11Short Squitter. The ADS-B over Satellite was the first experiment of its kind and a first step for demonstration and verification of space based air traffic surveillance.

The functional principle of space based ADS-B is shown in Fig. 2.

A typical detection pattern of the satellite can be seen in Fig. 3.

Fig 4 shows the accumulated tracks of over one year of observation.

Fig 5 shows the tracks of aircraft flying over north America in the direction to the oceanic route to Europe. Clearly can be seen, that tracking of aircraft is feasible using a space base ADS-B system. Fig. 6 shows the SAT-ADS-B tracks of aircraft close to Singapore airport.

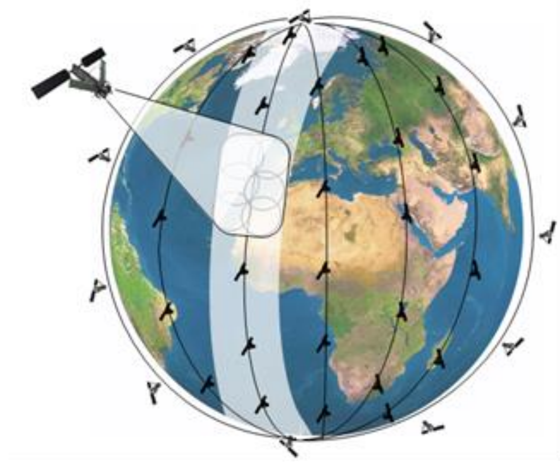

Fig. 2. Principle of satellite based ADS-B.

Fig. 3. Example Detection pattern of DLR's in orbit demonstrator with in one track (no accumulation over concurrent tracks) [X1].

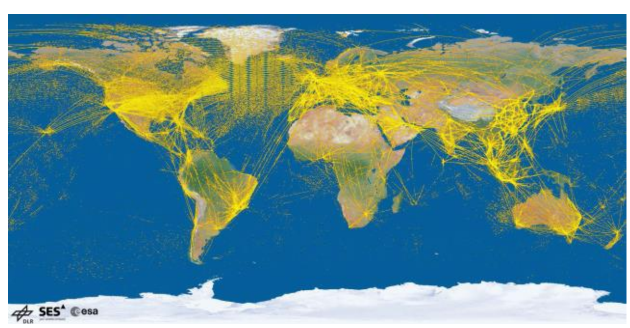

Fig. 4. Accumulated tracks of over one year of observation [1, 2].

Fig. 5. Aircraft tracks near and over the Hudson Bay [X1].

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Fig. 6. Tracking of aircraft at the the final of Singapore Changi Airport (ICAO Code WSSS) [X1].

The examples are a good demonstration of the capability of SAT-ADS-B to track on a global as well as on local scale with the same system.

To make full use of it, the data can be supplied via a System Wide Information Management System (SWIM) for all stake holders of the air transport system, see Fig 7 [3].

4. Airport Applications

Using the SWIM services, the information at small airports also can be improved. A flexible and cost-efficient Information Service for Small and Medium Airports can be developed. It aims to enhance airport safety approaches and departures by integrating aircraft surveillance information with SAT ADS-B in the vicinity of airfields. This enhancement of the situational awareness is achieved by methods of data fusion and integration of additional non-space data sets (e.g. weather information). The information can be visualized displaying the relevant and customized ancillary information layers in a user-friendly way. SAT-ADS-B will close the gap near to airports where ground-based reception of ADS-B data can be disturbed by shadowing effects, Fig 8, 9.

Within the planned ESA project AIRTRACKS a demonstration system for different users will be realised.

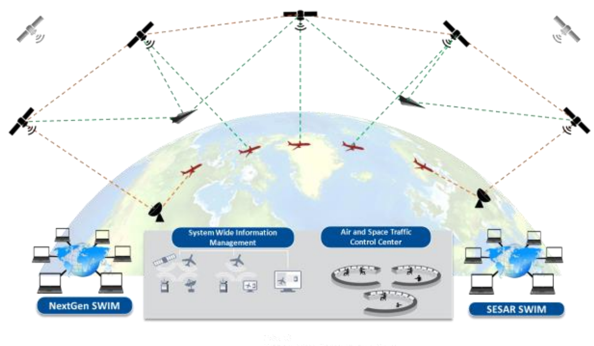

Fig. 7. International data exchange of SAT-ADS-B data via SWIM.

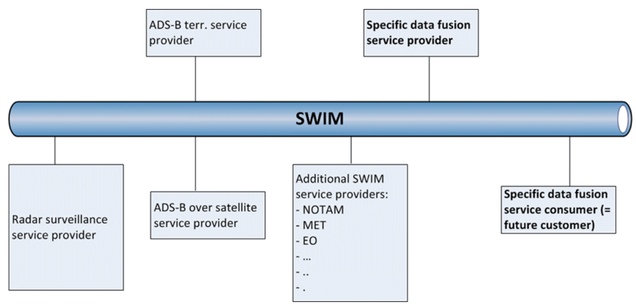

Fig. 8. AIRTRACKS system for enhanced situation awareness at airports

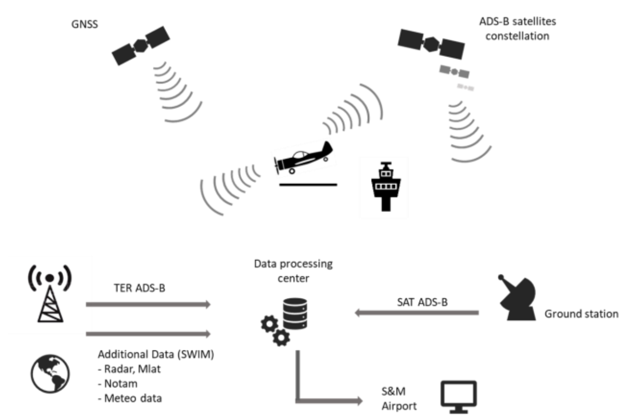

Fig. 9. AIRTRACKS concept for using different sources for situation awareness at airports

5. Conclusions

DLR's in orbit demonstrator is receiving SAT-ADS-B data in space in a reliable manner. Data analysis shows, that SAT-ADS-B can be used to track space vehicle operations on a world wide scale. The data can be incorporated in an interconnected SWIM system. In a special example, the demonstration system AIRTRACKS for small and medium airports is being developed.

Call for participants: Airports and airfields are kindly invited to join the project, share their current experiences and contribute to the identification of user needs.

Acknowledgements

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