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DISPLAYING THE AIR SITUATION THROUGH THE COLLECTION AND PROCESSING OF FLIGHT INFORMATION ON FLIGHTRADAR24 PROJECT

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Abstract: *In the present publication, the sources of flight data collected and processed on the Flightradar24 project are described. A description of the functioning of the system and its advantages, limitations and drawbacks is made. The improvement of Flightradar24 project capabilities by installing a monitoring station at the Technical University of Sofia is also mentioned.*

Keywords: *radar, radar station, ATC, flight safety, ADS-B, MLAT*

1. INTRODUCTION

The discovery of a target (aircraft, surface ships and other objects), the determination of its coordinates and motion parameters is performed by radar devices (radar stations or radars). They are designed to detect the target and determine its coordinates through the generation, transmission and reception of reflected radio signals, and in the case of secondary surveillance radar – by receiving signals transmitted by airborne transceiver (transponder) [1]. Therefore, the following tasks are performed:

1. Finding – establishing the existence of a target;
2. Determination (measurement) of the coordinates of the target;
3. Determination (calculation) of the movement parameters of the target by subsequent radar information processing [2].

Air traffic in the territory of the Republic of Bulgaria and international flights is organized within certain air corridors at which continuous radar surveillance must be established. This requirement appears to be a significant problem when flying over large bodies of water and over land in the presence of vast uninhabited areas where it is impossible to deploy radars (for example in Brazil, Russia etc.). One approach for solving this problem is the simultaneous use of several information sources. This approach is implemented in the Flightradar24 project [7].

2. BACKGROUND RESEARCH

In previous works the authors have studied the parameters and application of GNSS (Global Navigational Systems) and EGNOS (European Geostationary Navigation Overlay Service) in aviation, commercial in particular. Moreover, the radar data is still crucial to combat momentarily unreliable satellite navigation data [8][9]. These systems are irreplaceable in navigation, landing guidance etc. and they have proven sufficient in displaying the air situation by aggregating the data with radar information. However, such complex systems are unfeasible in monitoring all air traffic, unregulated air traffic in particular [10]. Another problem is that this information is not displayed publicly.

In the current study, an information service called Flightradar24 is described. This service aggregates flight and position data and offers the information to the public. It can be displayed to recreational pilots and UAV operators for situational awareness.

3. INFORMATION SOURCES IN FLIGHTRADAR24

Flightradar24 is a flight tracking service that shows live air traffic from around the world. *Flightradar24* combines data from several sources including ADS-B transponders, US Federal Aviation Administration (FAA) data and Multi-lateration measurements (MLAT).

The ADS-B, MLAT and FAA data is aggregated with schedule and flight status data from airlines and airports to create a unique flight tracking experience on the www.flightradar24.com site.

3.1. ADS-B Technology.

The primary technology Flightradar24 uses to receive flight information is called Automatic Dependent Surveillance-Broadcast (ADS-B) [3]. The ADS-B technology itself is best explained by the image below (Fig.1).

1. Aircraft gets its location from a GPS navigation source (Satellite);
2. The ADS-B transponder on aircraft transmits signal which includes the location of the aircraft among other data;
3. ADS-B signal is picked up by a receiver connected to Flightradar24;
4. Receiver feeds data to Flightradar24;

Data is shown on www.flightradar24.com.

FIG.1. Gathering data in the project Flightradar24 [4]

3.2. FAA data [5].

The flight data is received from the FAA in the United States. Unlike the ADS-B data which is presented in real-time, the FAA data is delayed by roughly 5 minutes due to FAA regulations. On the Flightradar24 map, all aircraft based on FAA data are colored differently.

FAA data is based on radar data (i. e. not just planes with ADS-B transponders) and includes most scheduled and commercial air traffic in the US and Canadian air space as well as parts of the Atlantic and Pacific Ocean.

3.3. Multilateration Tecnology (MLAT) [6].

Many aircrafts still rely on older type transponders (non-ADS-B transponder) to report flight information. A special receiver and the related software are developed for these aircraft within the Flightradar24 project in order to implement MLAT for flights tracking.

Multilateration is a common technique in long-range radio navigation systems, where it is known as hyperbolic navigation. Such systems are relatively simple because they do not require a common clock. A position is determined by measurements of the difference in distance to two transmitters at known locations that broadcast signals at known times.

Unlike absolute distance or angle measurements, measuring the difference in distance between two stations results in an infinite location solutions. When plotted, they form a hyperbolic curve. To locate the exact location, multilateration relies on multiple measurements. A second measurement is made, to a different pair of stations. This measurement will produce a second curve, intersecting with the first. When the curves are compared, a small number of possible locations are revealed, producing a “fix”.

3.3.1. MLAT limitations in the Flightradar24 project [7].

For Flightradar24 tracking MLAT requires 4 or more FR24-receivers in a region to receive a signal from the same aircraft. The next step is Time Difference of Arrival (TDOA) measurement – the time it takes the signal to reach the receiver. By comparing how long it takes the signal to reach each of the receivers, it is easy to determine the aircraft’s position and speed. MLAT position accuracy is comparable with that of ADS-B.

Flightradar24 team is stating they have achieved an accuracy of 10-20 meters. Speed is also calculated but errors are common in speed data, especially when making turns.

Processing the received MLAT data results in a small delay in the display of the aircraft positions –approximately 30-40 seconds. An issue affecting mainly MLAT flights outside of Europe is the absence of call-sign information, which makes matching the correct flight route information very difficult. Route information is not transmitted by the aircraft, so the call-sign must be compared with flight and schedule databases to determine and display the route. When tracking via MLAT is possible and the call-sign is missing, a difficulty determining the route information is present.

Due to the high frequency used (1090 MHz) the coverage from each receiver is limited to about 250-450 km (150-250 miles) in all directions depending on location. The farther away from the receiver the aircraft is flying, the higher it must fly to be covered by the receiver. The distance limit makes it very difficult to get ADS-B and MLAT coverage over oceans.

3.3.2. MLAT coverage under project Flightradar24.

Most parts of Europe and North America are today covered with MLAT above about 5,000-10,000 feet (1,500-3,000 meters). There is also some MLAT coverage in Mexico, Brazil, South Africa, Japan, Taiwan, Thailand, Malaysia, Indonesia, Australia and New Zealand; MLAT coverage is under continuous expansion in South Africa, South America, China, South Korea, Japan and Russia.

In some locations Flightradar24 project has achieved MLAT coverage below 1500 feet (450 meters), including Amsterdam, Stockholm, Toulouse, Reykjavik, Chicago.

4. FLIGHTRADAR24 PROJECT IN BULGARIA

As stated above, MLAT requires 4 or more FR24-receivers in a region to receive signals from the same aircraft. In general this requirement limits the MLAT’s coverage above 5,000-10,000 feet as the probability that four or more receivers can receive the same transponder’s signal increases with increased altitude. So it is simple to understand that the number of FR24-receivers located in a region must be high.

Flightradar24 has a network of more than 7,000 ADS-B receivers, shown on Fig. 2.

In March 2015 a FR24-receiver has been installed in the Department of Air Transport at the Technical University of Sofia. The device has been provided by the FR24 team and is part of the FR24 monitoring network. The equipment installed on the roof of Block 10 of a Technical University consist of (Fig. 3):

- Mode S/ADS-B FR24-receiver;
- Mode S omnidirecional antenna;
- GPS antenna.

The connections between elements is given on Fig. 4.

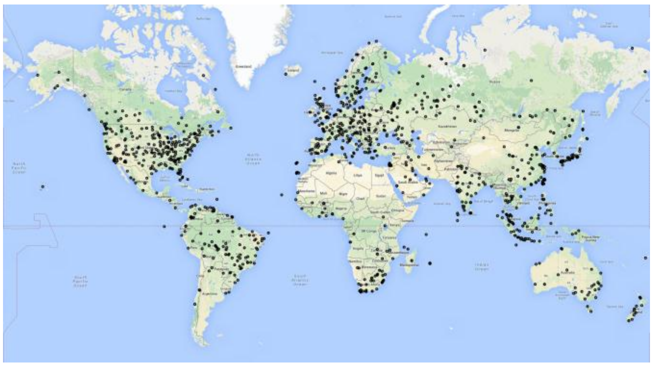

FIG. 2. Map of receivers activated in January-June 2015 [7]

FIG. 3. Specialized equipment to monitor aircraft in real time

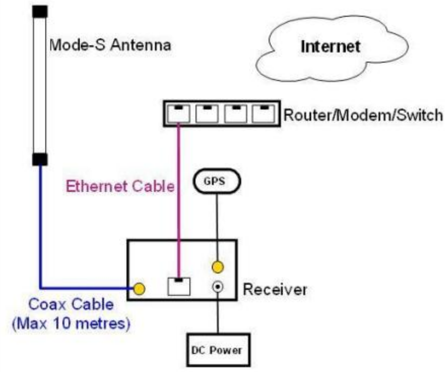

FIG. 4. Schematic diagram

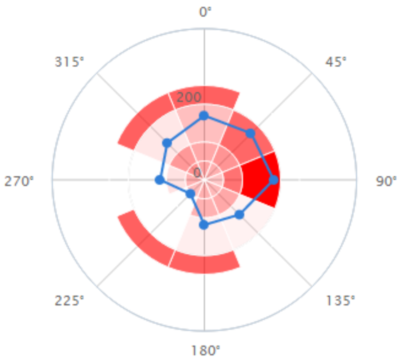

FIG.5. Daily plot of the registered aircrafts by the FR-24 receiver at TU-Sofia (range shown in nautical miles)

The receiver gets signals from aircraft transponders (ADS-B or older). Received signals are sent to the FR24 data server, where depending on the type of transponder from which the signals are received the necessary processing or measurements is made and the results are displayed on the site in form of moving targets (aircraft, helicopters and more).

Installing the receiver of the Flightradar24 monitoring network at the TU-Sofia have improved the capabilities for monitoring and positioning of aircraft located at altitudes below 450 m significantly, i.e. all departing and landing aircraft at Sofia Airport. This is a particularly valuable contribution, especially having in mind the presence of high natural obstacles as Vitosha Mountain (11 kilometers away from the airport) and limiting the possibility of receiving signals from other monitoring stations in a wide sector in the west direction. A typical polar plot of the range of the daily registered aircrafts by the FR24 receiver at TU-Sofia could be seen on Fig. 5.

CONCLUSIONS

In recent years the unregulated air traffic tends to increase. The rapdly expanding UAV market for the general public neccesitates the creation of a public source of information on all air traffic. Flightradar24 project shows clearly how the opportunities for air situation display in real time are increased by combining flight information from different sources and by appropriate data processing, without the need to use traditional methods for radar surveillance and offering the gathered information to the public.

The only drawback of the Flightradar24 project is the inability to observe and depict aircraft without switched on or with damaged transponders.

By integrating and processing flight information from different sources, the possibilities for monitoring and display of the air situation in real time is improved, including overlarge areas with no radar surveillance. This will significantly improve the opportunities for ATC in these areas, which in turn will lead to increased flight safety.

The introduction of systems that collect and process flight information from different sources is a promising direction, which in many cases may be the only possible solution to ensure the process of ATC over areas without radar coverage.

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REFERENCES

[1] Korobko, I., *Radiolocation Systems and Devices. Part I – Radiolocation basics*, Sofia, 2002.
[2] Korobko, I., *Radio-technical Systems,* Sofia, 2003.
[3] Radarspotters Team, *Simply about complicated – ADS-B (Automatic Dependent Surveillance-Broadcast)*, http://www.adsbradar.ru, 2013.
[4] Radarspotters Team, *ADS-B Technology (TIS-B, FIS-B)* – photo, http://www.adsbradar.ru, 2013.
[5] Federal Aviation Administration, *About FAA*, http://www.faa.gov, 10 June 2015.
[6] Radarspotters Team, *Multilateration – MLAT*, http://www.adsbradar.ru, 2013.
[7] Flightradar24, *New Flightradar24 Receivers Activated in the First Half of 2015,* New Flightradar24 Receivers Activated January through June 2015 – photo on http://www.flightradar24.com, 2015.
[8] Kalagireva K., Vassilev B., *Comparative Analysis of the Algorithms for Determination of the Egnos Performance Indicators*, 22-nd Saint Petersburg International Conference on Integrated Navigation Systems, 25-27 May 2015.
[9] Kalagireva K., Comparison of the Efficiency of EGNOS Parameter Determination Algorithms, BulTrans-2014 International Conference Proceedings, Sozopol, 2014.
[10] *EGNOS Cost Benefit Analysis in Aviation*, GSA – GNSS Supervisory Authority, 27 July 2009, http://www.lek.com, 2015.