Journal of Open Aviation Science (2023), Vol.**1**
doi:10.59490/joas.2023.7221

JOAS

POSTER | *The 11th OpenSky Symposium*

Improving light aviation safety through traffic sharing of OpenSky ADS-B feed in Airmate app

Daniel Mavrakis* and François Zannin

Myriel Aviation, 5, rue Heienhaff, L-1736 Senningerberg, Luxembourg

*Corresponding author: mavrakis.daniel@airmate.aero

(This poster paper is not peer reviewed.)

Abstract

Traffic detection and alerting is lacking in light and ultralight aviation aircrafts for several reasons:

- those aircrafts mostly operate in lower airspace, often near the ground, and may not be detected by ATC radar network.
- they may either not be transponder-equipped or not operating their transponder, especially in uncontrolled lower airspace.
- Most of those small aircrafts are not equipped with onboard ADS-B receivers.
- Pilots may not be in touch with ATC information frequencies and hence will not get traffic alerts from ATC.

To increase safety of such flights, we added the display of surrounding traffic to the Airmate EFB (Electronic Flight Bag) and relevant informational traffic alerts when a potential conflict is detected. Airmate is the most used free application for flight planning and navigation, with a community of more than 230,000 pilots worldwide. The Airmate EFB is now able to display neighbouring traffic consolidated from OpenSky and other hubs, and broadcasted to flying pilots over mobile network connectivity.

The sharing of position reports from Airmate app enables to complement ADS-B traffic with actual data from aircrafts that may not be detected by ATC radar network.

Traffic sharing prerequisites is to be within coverage of a mobile network and running the Airmate app while flying. An Airmate server is receiving ADS-B traffic from OpenSky and other hubs, FLARM and GliderNet traffic, merging it with Airmate position reports received from Airmate apps in flight mode. The consolidated data is then broadcasted to pilots flying using Airmate EFB if within mobile network coverage.

Keywords: ADS-B; OpenSky; Airmate; GliderNet; TCAS

Abbreviations: JOAS: Journal of Open Aviation Science, ATM: Air Traffic Managment

1. Introduction

This presentation focuses on traffic awareness for non-commercially operated small aeroplanes, mostly light aircrafts weighting less than 2,000 kg and ultralight aircrafts.

Mid-air collisions represent a significant part of the casualties incurred by general aviation flights, with 140 occurrences recorded by EASA in the 2011-2020 period [1]. Most aircraft accidents happen during the takeoff and landing phases of the flight.

We study how a traffic alerting system based on traffic data received over a mobile network from OpenSky and other hubs may improve safety by providing traffic awareness to light aircraft pilots.

2. Aircraft tracking systems

Aircrafts are often equipped of tracking devices aimed to report their position, this position reporting may be used to detect and warn about potential conflicts.

The position reporting devices include:

- **Transponders**, mandated in all commercial aircrafts and general aviation aircrafts flying in transponder mandatory airspace. Standard transponders are detected by ground receivers usually associated with radar stations, mode C transponders are also broadcasting flown altitude flight level, most recent ADS-B transponders are broadcasting aircraft identification in the form of ICAO 24-bit assigned code and flight parameters (geographical position, track, speed, altitude, vertical speed).
- **FLARM devices**, mostly used in the glider world (by gliders, powered gliders and tow planes) are small and relatively inexpensive devices using a proprietary technology to broadcast aircraft flight parameters over an open frequency [2]. FLARM tranceivers can then warn the pilot if another aircraft is detected nearby.
- Using a similar approach, **other proprietary devices** have been developed over the years, they include PilotAware [3], Neuron, Open Glider Network (OGN) and others. They broadcast aircraft location over an open frequency to allow detection by nearby aircrafts using the same receiver brand and sometimes by ground stations.
- Proprietary mobile apps may also broadcast aircraft flight parameters and receive neighbouring aircraft data consolidated from hubs, they require network coverage to run.

3. Aircraft collision prevention

Taking into account the number of aircrafts flying at a given time and the available airspace size, the probability of two given aircrafts being at the same place at the same time and hence mid-air collision is rather low [4] [5] [6].

This is why most mid-air collisions happen during takeoff or landing phases of the flight, during formation flying and between gliders flying along the same uplifts. In those cases, aircrafts are following close flight paths and therefore more prone to collision (for cruising aircrafts, the standard separation requirements are 5 NM horizontally and 1000 ft vertically).

Collision prevention relies on:

- **See and avoid**: although taught from the beginning to all student pilots, it has been demonstrated that it is very difficult for a pilot, even properly looking around, to detect another aircraft in the vicinity. This is even true when an ATC controller or an onboard device has warned the pilot of a potential conflict indicating conflict direction and distance.
- **Air Traffic Control alerting**: when the two aircrafts are transponder-equipped and detected on a conflictual course by ATC controllers, they will warn both pilots of the collision risk, so they could look around.
- **TCAS (certified) and non-certified devices** installed on board could receive and analyze ADS-B traffic to automatically detect conflicts and sometimes provide resolution advisories or instructions [7].

It is worth noting that many traffic will not be detected by ATC controllers, including:

- Transponder-equipped aircrafts flying at low altitude outside coverage of a ground station.

- Aircrafts not equipped with transponders but with other devices such FLARM, or not equipped with any traffic reporting device.
- Many general aviation pilots may also be reluctant to turn on their transponders in areas where transponders are not required, as they don't want ATC to know their exact location.

4. Onboard traffic alerting devices

To complement the see-and-avoid mechanism and flight following and alerting by ATC, pilots may rely on on-board equipment [8]:

- Airliners and commercial aircrafts are mandatorily TCAS-equipped.
- Gliders and tow planes are usually FLARM equipped.
- For general aviation light aircraft, inexpensive ADS-B receivers are available. With a price range between €100 - €700, they can receive ADS-B transmissions and sometimes FLARM transmissions. The user interface and traffic warning are displayed by the pilot preferred aviation app used for navigation. Most aviation apps will display ADS-B traffic received by an external ADS-B device, connected over Wifi interface or Bluetooth (including Airmate, Air Navigation Pro, FlyQ, ForeFlight, SkyDemon, WingX and others).

Only a small percentage of light aircrafts are equipped with onboard traffic alerting equipment. Even if ADS-B receivers are not very expensive (medium price around 300€), most general aviation pilots don't invest in them and are therefore unaware of surrounding ADS-B traffic.

Many free or inexpensive mobile apps can display to pilots traffic received from hubs over the mobile network, including ADSB Flight Tracker, AvTraffic, OGN Transceiver, OGN Radar, OpenADSB, SafeSky and others. The main drawback of those apps dedicated to displaying traffic is that most pilots are already using their phone or tablet to run their preferred aviation or Electronic Flight Bag (EFB) app as they don't want to focus only on traffic display. Some of those apps may forward the received traffic to EFBs running on the same device.

5. Using Airmate free Electronic Flight Bag for traffic awareness

Airmate free Electronic Flight Bag is the most used worldwide flight planning application for general aviation users, with more than 230,000 users worldwide as of September 2023 [9].

Airmate provides pilots with all information needed to prepare and execute their flights, including aeronautical weather, aviation warning such as NOTAMs, aeronautical charts, airport diagrams and approach plates, flight plan filing, flight path recording and traffic display. As with nearly all EFBs, neither the app or the iOS or Android devices are certified; they should be used as a primary method for flight planning or navigation, even if most data is sourced from aviation authorities.

To improve safety, latest Airmate iOS release includes an experimental data feed allowing Airmate to display nearby traffic from OpenSky ADS-B hub, other ADS-B hubs and OpenGlider hub. As all major EFBs, Airmate is of course also able to display traffic detected by an onboard ADS-B or FLARM traffic receiver [9].

Traffic data is displayed on top of the aeronautical map used by the pilot to track his navigation. In case of potential conflict, a TCAS-like window is used to display neighbouring traffic.

Specific limitations apply to this traffic display method:

- Network traffic reception and transmission requires the app to be connected to GSM base station with a sufficient quality to enable GPRS data reception. Data reception is usually lost when no base station is nearby, including when the aircraft will flight at higher altitudes. Above flight levels 80

to 100, network reception is usually lost most of the time. On the other hand, at high altitude, aircrafts will be detected by ATC.
- Relaying through ground stations, hubs and Airmate server induce delays so the aircraft location can significantly differ from the one displayed on the device when the traffic packet is received. A latency of 3 seconds in the whole chain will result in an offset of 250 meters (assuming a light aircraft cruising at 300 km/h).
- Only the traffic received by ground stations and forwarded to hubs will be displayed.

6. Technical implementation

The traffic awareness feature is implemented using a client/server model:

- An Airmate server hub is connected to OpenSky and other traffic hubs (including GliderNet). It also receives traffic data from Airmate client apps. The Airmate server hub consolidates traffic received from those different sources and perform appropriate deduplication as some traffic may be received by different hubs. It then redistribute data to Airmate clients.
- The Airmate client app registers with the Airmate server to request the sending of all traffic in a bounding box around the aircraft. The server will only send traffic pertaining to the subscribed bounding box to lower as possible the network traffic.

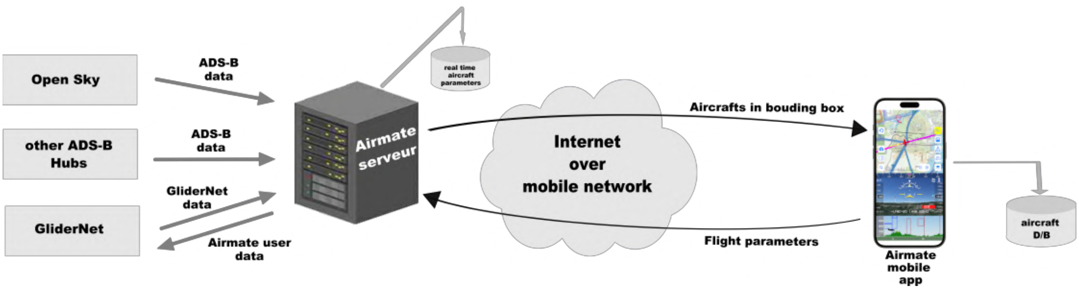

Figure 1. Client/Server architecture for Airmate network traffic display

Airmate app is also broadcasting its own traffic data to the Airmate server hub, ensuring Airmate users will be shown other users nearby even if they are not detected by any ground station.

To increase general aviation safety, Airmate server hub is also sharing Airmate traffic with open Hubs such as GliderNet, allowing pilots using GliderNet app or other traffic display apps to view Airmate traffic.

7. Challenges and improvements

The following improvements are planning to be implemented in a next version of the app:

- Improved bounding box traffic filtering.
- Probabilistic trajectory computation: a few seconds delay may elapse between the data packet transmission from the aircraft and its on board reception by the Airmate app. Data is first received by ground stations, transmitted to the OpenSky (or another) hub, transmitted by the Airmate server hub, and then rebroadcasted to client apps. Especially if a confict risk is identified, the conflicting aircraft position may have evolved significatively in this period. Using aircraft parameters specified in last received packet and elapsed time, a forecasted aircraft position at display time will be shown.
- Improved TCAS display showing target flight path directions and forecasted positions.

- Feedback and statistics: we are implementing appropriate tools to be able to receive statistical information on traffic conflicts detected and their usefulness to the pilot.
- Android implementation providing the same traffic display feature than the iOS version.

8. Conclusion

Integrating traffic display in the most used Electronic Flight Bag worldwide is aimed to provide additional safety awareness of neighboring traffic for light and general aviation pilots.

Given the significant position error induced by the delays in the processing chain, this feature will always be unable to achieve the accuracy and resolution advisory capabilities of TCAS platforms, but it may bring potential conflicting traffic to the pilot attention, to help the see and avoid process.

In addition to manned aircrafts, such technology may prove invaluable in helping to deconflict general aviation and drone traffic [3] [6].

Author contributions

- Daniel Mavrakis: Conceptualization, Methodology, client software writing, paper writing
- Francois Zannin: Server software writing, Paper review

Funding statement

This research has been funded by Myriel Aviation SA.

Open data statement

This implementation is using real-time open traffic data received from ADS-B hubs such OpenSky, from GliderNet hub and from Airmate mobile clients.

Reproducibility statement

Airmate data is broadcasted to GliderNet, ensuring other mobile apps could receive and process the same traffic data in the interest of flight safety.

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