Progress Report
Wireless Networking

Airplane Tracking Using ADS-B Signals

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1 Introduction

Wireless networking constitutes the key enabler of modern communications, given the myriad different use cases and applications. The wireless networking revolution brought fundamental changes to the way communications are set and implemented. Aim of this project is to offer us the opportunity to get acquainted with the reception of real-time packets. Thanks to a RTL-SDR dongle, the transmission and reception of wireless signals in real time is accomplished and the analysis and measurements of those are enabled across a broad frequency range.

The project focuses on airplane surveillance signals (ADB-S) and aims to discover a variety of aspects referred to air-traffic tracking. Automatic dependent surveillance-broadcast (ADS-B) is a new found technology in which aircrafts determine their position and periodically broadcast it, and it constitutes the primary method of air traffic control and surveillance. Modern airplanes use an ADS-B Mode-S transponder, in order to send to the air-traffic controllers their location, with improved precision and timing, enhancing aviation infrastructure and operations.

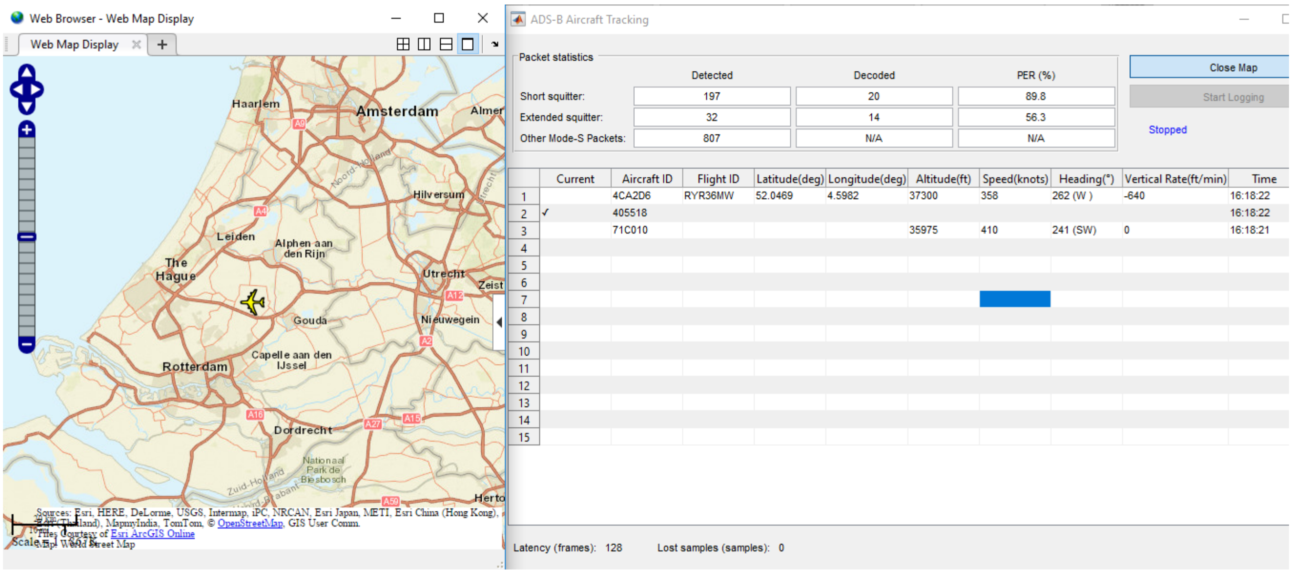
The signal to be analyzed is that of aircrafts sent out in order to be received by other aircrafts, vehicles or ground stations equipped to receive ADS-B. This broadcasting, is usually referred to as "ADS-B Out". ADS-B out periodically broadcasts information about each aircraft, such as identification, current position, altitude, and velocity, through an on-board transmitter. These unencrypted signals provide anyone with the chance to receive and decode them.

Main focus of this assignment is the code analysis and improvement in the way the signals are received and decoded. Furthermore, the conditions under which our receiver works best will be tested. To be more specific, distance from the source, environmental conditions like weather, temperature conditions are some of the features that are going to be examined. The purpose of these tests, is to check the influence of multi-path propagation and attenuation to the signals. Moreover, as it has been reported, improved reception can be achieved after applying a 1090 MHz band pass filter. For that reason a band bass filter will be in our priorities to be applied in the setup.

2 Tools

Using Simulink and Communication System Toolbox we familiarized ourselves with tracking planes, by processing ADB-S signals. The above mentioned in combination with a RTL-SDR dongle and 'Airplane Tracking Using ADS-B Signals' package fulfilled the reception of decoded signals. A former installation and configuration of the required drivers took place. The proper operation of signal detection was tested by the included examples of the ADS-B package, resulting in the detection of the available aircrafts and the successful real-time display of their location data.

Figure 2.1: The 'Airplane Tracking' package GUI in Matlab.



Code modifications and tests were the following step. To do so, code had to be revisited and examined in depth as it can be very difficult to intervene into someone's code if its functionality has not been fully understand. The first step towards that direction was the full understatement of the set up of this communication system and the inside implementation of the source files.

3 ADB-S Decoding

ADB-S is a satellite based surveillance system that transmits information through MODE-S Extended Squitter at 1090MHz.

Every ADB-S message is 112 bits long and consists of 5 parts that are explained in the Figure below.

Figure 3.1: ADB-S Messages.

```
+--------+--------+-----------+------------------------+---------+
|  DF 5  |  ** 3  |  ICAO 24  |          DATA 56       |  PI 24  |
+-----------------+-----------+------------------------+---------+
```

This table lists the key bits of a message:

nBits	Bits	Abbr.	Name
5	1 - 5	DF	Downlink Format (17)
3	6 - 8	CA	Capability (additional identifier)
24	9- 32	ICAO	ICAO aircraft address
56	33 - 88	DATA	Data
	[33 - 37]	[TC]	Type code
24	89 - 112	PI	Parity/Interrogator ID

The process of decoding ADB-s Signals is explained in depth in 'ADS-B Decoding Guide' which is open-source.

4 Trials

In this chapter the tests that were performed using the equipment mentioned above are displayed. The equipment includes two stations with exactly the same characteristics, same Matlab configuration and installations and versions of ADS-B air signal packages. The only difference is that one antenna has been used for a year and the other is a brand new.

The first experiment was taken to determine the difference in signal reception of the two antennas. The two stations were put next to each other and they were receiving packets for 3 minutes at the same time. The outputs of the new antenna will always be presented at the left side.

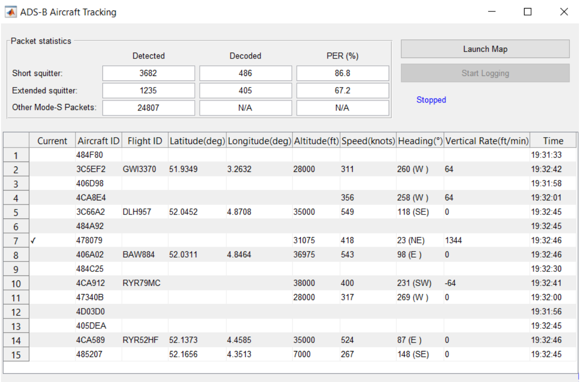


Figure 4.1: New Antenna.

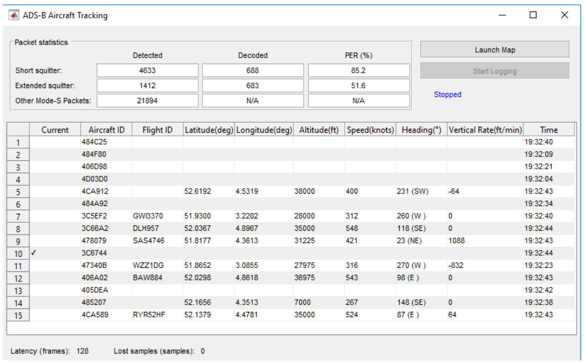


Figure 4.2: Old Antenna.

As it can be observed, while the new antenna receives more S-Mode packets, the old one is able to receive more Squitter packets. The difference lies to the fact that the first antenna is able to fully decode 5 airplane flight details while the second one 6 of them.

The second experiment that was carried out presents the difference in the signal reception in different positions regarding the height that the antenna was positioned. The first image shows the results exported on the base floor of the EWI building while the second one concerns the results on the 20th floor. The signal reception once again took place simultaneously.

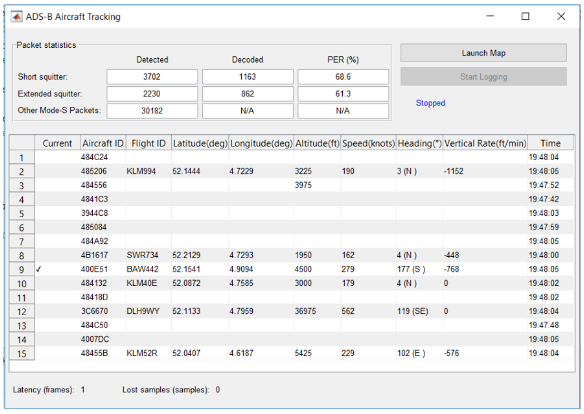


Figure 4.3: New Antenna on 20th floor.

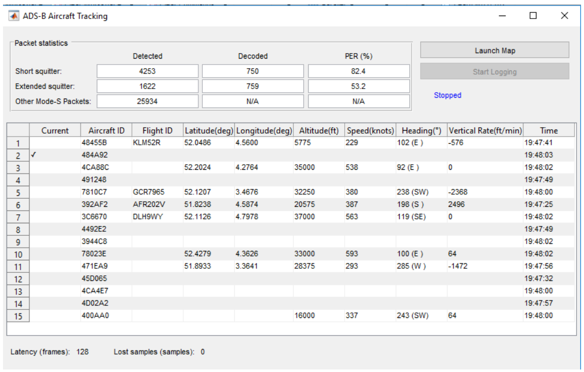


Figure 4.4: Old Antenna on base floor.

As it can be conceived from the above images, the difference between the signals received is now more significant than before. On the 20th floor, the S-Mode packets received are way more and the flight IDs are now 6 in comparison with those on the base floor, which were only 4.

According to the quick start guide of the rtl-sdr dongle, the best results can be obtained if the dongle is placed on a metallic surface. Our antennas exhibited the following results.

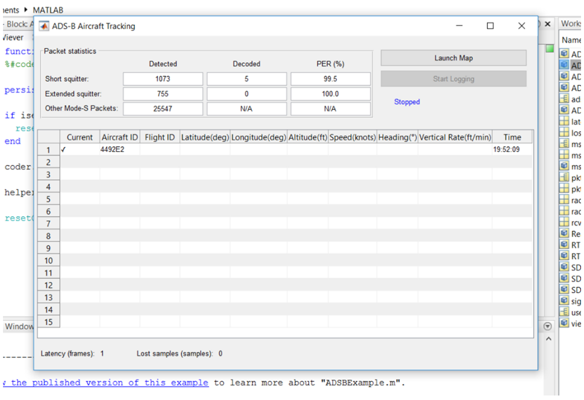


Figure 4.5: New Antenna on 20th floor.

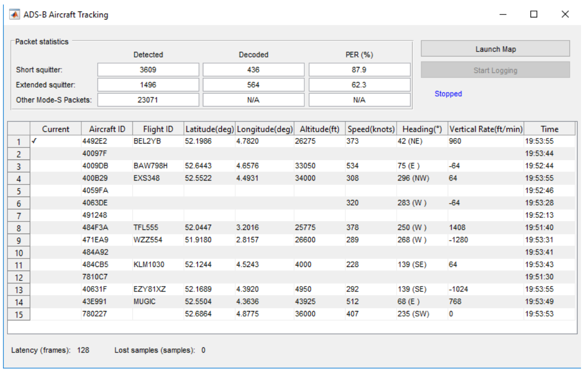


Figure 4.6: Old Antenna on base floor.

Although the packets on the left hand side image are received, they do not seem to be decoded for some reason. This result will become a subject for further investigation, as it seems an interesting fact.

A third experiment was carried out in order to examine the influence of gain in terms of signal strength throughout the frequency spectrum. Increasing the gain slider with respect to noise restrictions, the signal strength may be amplified considerably.

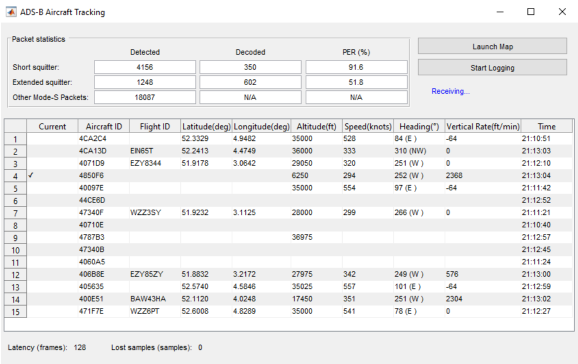


Figure 4.7: Tuner Gain 90bd

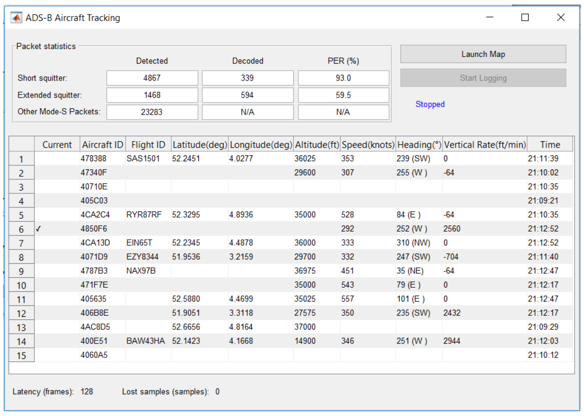


Figure 4.8: Tuner gain 60db

During the execution of the experiment though, no such improvement was noticed, as the tuner gain was increased up to 90 db. Further trials will be carried out in order the optimal gain to be discovered.

Tuning the radio on an RTL SDR receiver, it's very common to find the frequency read-out to be wildly inaccurate. Frequency correction parameters used as an error correction in ppm (parts per million) in order to adjust and correct the device at the software side of operation. We search for this unique PPM value for our RTL USB dongle. We executed one experiment with an increased frequency correction value at 20ppm. We collected the results by using simultaneously a dongle with frequency correction 0ppm and another with 20 ppm and they are presented in the above images.

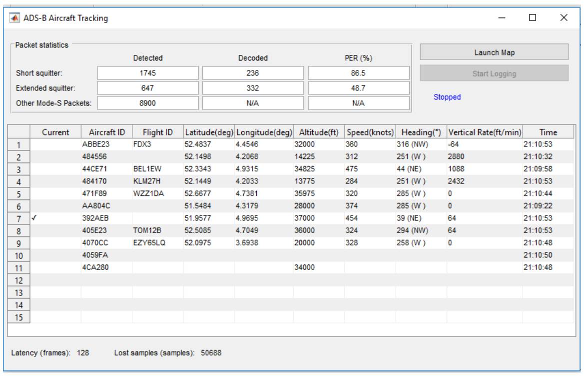


Figure 4.9: Frequency correction 20ppm

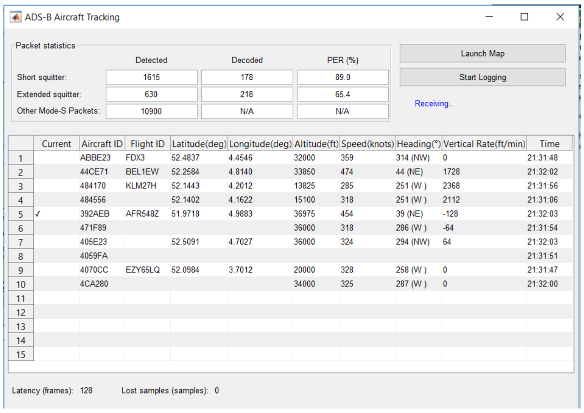


Figure 4.10: Frequency correction 0ppm

The differences are not significant, a fact that means that we should try to find the ideal frequency correction with the use of the SDRSharp tool.

5 Objectives and Strategies

The assignment aims to the implementation of our own analysis methodology in an already existing system, based on mathematical tools and simulations. The system that was selected receives packages real-time and decodes them providing the desired information.

Our aim is, by changing some parameters that affect the way of packet reception, to improve the acquired output. In later stages, changes may be applied to the code itself, in order to test if these changes enhance the way code operates.

Also, tests will be conducted with respect to determine under which circumstances the reception of the real-time packets performs best. These tests will include reception from different places, closer to the source of the desired signals which are provided by the airplanes, changes in the temperature of the antenna and reception from various heights.

Last but not least, to improve the accuracy of the current setup we would like to check if the Triangular technique would be applicable in this case.