SOUTH DAKOTA SCHOOL OF MINES & TECHNOLOGY

Development of Affordable *Automatic Dependent Surveillance – Broadcast* (ADS-B)

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Introduction

ADS-B is a part of the FAA's NextGen plan to upgrade air traffic infrastructure that will replace conventional ground based radar. ADS-B devices on aircraft have two functions:

- In: This system receives real time traffic (from ground stations and other aircraft) and weather data (from ground stations) that can be displayed in cockpit.
- Out: Broadcasts an aircraft's navigational information encoded in a 112 bit ADS-B data message that includes: aircraft ID, GPS coordinates, velocity, and heading.

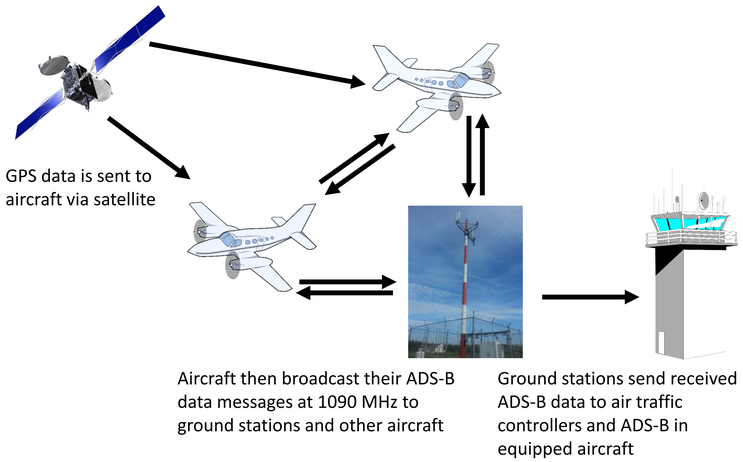

Fig. 1 - Visual representation of ADS-B

Pilots may purchase an ADS-B device that comes with either in, out or both in/out functionality.

The FAA has mandated that all general aviation aircraft be equipped with ADS-B out by the year 2020, and to do this 1,000 to 2,000 aircraft would need to be equipped every month. Right now, that number is only 500 to 700 per month. A major reason for the low adoption rate is the current price of roughly $5,000 for ADS-B equipment and installation.

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Objective

To begin development of an ADS-B out system prototype that meets the 2020 mandate and is cheaper than the current market average cost.

Hardware

Raspberry Pi 3 Model B
- Common microcontroller
- Easy to use
- Built-in Wi-Fi allows remote access to system

Fig. 2 - Raspberry Pi 3

HackRF One
- Software define radio (SDR) capable of broadcasting/receiving
- Large open source community
- High sample rate, 20 million per sec

Fig. 3 - HackRF One

Software

GNUradio
- Free open source SDR toolkit
- Block diagram interface writes code in Python

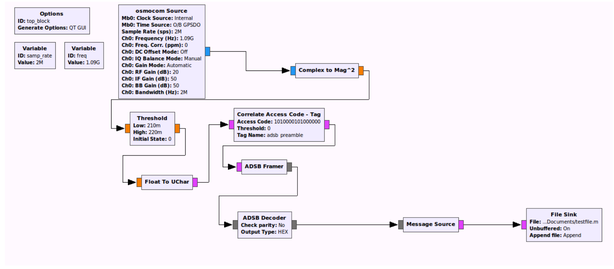


Fig. 4 - Flow graph showing ADS-B decoding

Image References

Fig. 1:
D. (2015, April 02). Airport Control Tower [Digital image]. Retrieved July 26, 2016, from https://openclipart.org/detail/216736/airport-control-tower

J. (2008, May 8). Cessna [Digital image]. Retrieved July 26, 2016, from https://openclipart.org/detail/16689/cessna

Satellite [Stock photo of satellite]. (2014). Retrieved July 26, 2016, from http://www.traxoid.com/Solutions/VehicleTracking.aspx

Fig. 3:
HackRF One. (n.d.). Retrieved July 18, 2016, from https://greatscottgadgets.com/hackrf/

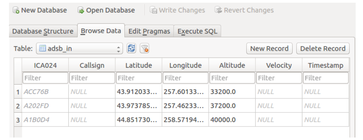
Fig. 4:
Raspberry Pi 3 Model B Motherboard. (n.d.). Retrieved July 20, 2016, from https://www.amazon.com/Raspberry-Pi-RASP-PI-3-Model-Motherboard/dp/B01CD5VC92/ref=sr_1_3?ie=UTF8

Results

GNU Radio Companion was used with the HackRF One to receive 112 bit ADS-B messages that were than converted to hexadecimal words, shown right.

```
*8DACC76B99519B9E8808360516E6;
*8DACC76B58AB01671348FA513C1D;
*8DACC76B99519B9E8808360516E6;
*8DACC76BF8000000003928435053;
*8DACC76B99519A9E80043620E420;
*8DACC76BE908AA276138106AC84E;
*8DACC76B58A9F4E52DE2BF6B16EB;
*5DACC76BC00E82;
*5DAD6758F44794;
*5DAD6758F44794;
*5DAD6758F44794;
*8DACC76B99514C9E680436B40565;
*8DACC76BF8000000003928435053;
*8DACC76B58A9F4D4CFF10C4A6DA2;
*5DACC76BC00E82;
*8DACC76B9951BA98800C36C9DE0A;
*8DACC76B9951BB98400836921E3B;
*8DACC76BE908AA26F138107675A0;
*8DACC76B58AB014D4963664D8EF6;
*5DACC76BC00E82;
*8DACC76B9951BB98A804376E92EC;
*8DACC76B58AB01465368C1B0A25C;
*8DACC76B58AB04C94FFE47618CB0;
```

Then, our program was used to decode the hexadecimal words. These words were decoded using compact position reporting (CPR) and ADS-B formatting as defined in the technical standard: RTCA/DO-260B.



Finally, Google Maps was used to display the location of the received ADS-B messages. These locations were verified using other ADS-B software.

Future Work

- Use experiences from coding the in system to code the out system
- Integrate a GPS source into the Raspberry Pi - *currently in progress*
- Deploy an ADS-B system to a remote Raspberry Pi
- Develop prototype in compliance with technical standards:
  - TSO-C166b, *Extended Squitter ADS-B and Traffic Information Service – Broadcast (TIS-B) Equipment Operating on the Radio Frequency of 1090 Megahertz*
  - RTCA/DO-260B, *Minimum Operational Performance Standards for 1090 MHz Extended Squitter ADS-B and TIS-B*
  - 14 CFR 91.227, *ADS-B Out Equipment Performance Requirements*