Disclaimer:
This document is intended to document and analyze the performance of the Open Source ADS-B Receiver (aka Stratux) Project. All data in this analysis was collected from the author's Open Source ADS-B Receiver Build. Due to variations in component selection and packaging of the Receiver project the performance of other Open Source ADS-B Receivers may differ from those of the author.

Introduction:
This document series was spawned after the author performed a receive performance analysis of a Straux build. That analysis showed there were some operational parameters that merited further study. The purpose of this series is to analyze those parameters, explore ways to improve performance, and present various design improvements for discussion and consideration.

Stratux Build used for this evaluation:
EdiMax Wi-Fi Dongle
Dual NooElec 820T2 dongles (the originally specified 820T2 dongles)
Raspberry PI - Vilros Kit
5V DC Fan
2V USB Wall Wart Power Supply
SMA - MCX pigtails to interface to the antenna port on the SDR dongle

Input Impedance (Dongle Impedance):
The first objective was to determine the antenna input impedance of the RTL-SDR dongles. Documentation is hard to find, but what is available implies the input impedance is 75 ohms. An HP Network analyzer was used to measure the input impedance of the dongles at 978 MHz and 1090 MHz. The measurements were taken at "turn on" and were monitored through 30 minutes of operation allowing the operating temperature of the dongles to stabilize. The input impedance did not vary appreciably during the test period.

Input Impedance Dongle 1 (Named stratux:978):
978 MHz = 36.9 -j10.9 Ohms
1090 MHz = 27.7+24.6 Ohms

Input impedance Dongle 2 (Named stratux:1090)
978 MHz = 32.2 -j13.5 Ohms
1090 MHz = 24.6+j25.3 Ohms

The measurements show the input impedance at the Stratux receive frequencies is about half to a third less than the published impedance of 75 Ohms. The dongles range from 60 Ohms to 80 Ohms within the TV band, but they vary greatly above that frequency. The antenna input also becomes more reactive as the frequency moves toward 1 GHz.

Homebrew Monopole Antenna Characteristics:
The author's ADS-B receiver build includes two homebrew monopole antennas. One is tuned to 1090 MHz and the other is turned to 978 MHz. The 1090 MHz antenna is a shortened Bazooka vertical that employs a capacitive top hat for tuning. (It is "shorted" because the author got too exuberant with tuning the antenna and didn't what to pitch a good piece of coax.) The 978 Antenna is half wave Bazooka vertical. These are the measured impedances of the antennas:

1090 MHz Antenna:
- 978 MHz = 10+j81 ohms
- 1090 MHz = 45-j21 ohms

978 MHz Antenna:
- 978 MHz = 43+j32 ohms
- 1090 MHz = 42.2 +j65 ohms

The antenna on the left is the 1090 MHz antenna and the one in the right is the 978 MHz antenna.

As this project progresses additional antennas that are suggested for use with the Stratux receiver may also be analyzed.

SMA “T” Splitter:

There has been discussion on Reddit concerning using a splitter and a single antenna with Stratux. The author built a typical splitter that had been discussed. The design was installed and tested in the Stratux build. In addition, the splitter was characterized separate from the build to quantify its impedance and loss parameters. The following are those measurements:

SMA Female x3 “T”
x2 12” SMA (M) RG-174 Cable
x2 SMA(F) SMA(M) Rt Angle connector
Input Port: S_{11}
1090 MHz Dongle Port: S_{22}
978 MHz Dongle Port: S_{33}

These are the measured characteristics of the splitter:

Parameter	978 MHz	1090 MHz	Unit
S11 Imp	27.6+j13.5	31.2+j13.2	Ohms
S11 Rtn Loss	-9.6	-11	dB
S11 PHA	139	135	Degrees
S11 VSWR	1.9:1	1.7:1	SWR
S21 Ins Loss	-3.8	-3.8	dB
S21 PHA	150.1	86.4	Degrees
S12 Ins Loss	-3.8	-3.7	dB
S12 PHA	150	86.4	Phase
S22 Imp	34.7+j23.5	98.4-j20	Ohms
S22 Rtn Loss	-9.9	-9.9	dB
S22 PHA	117.24	-15.8	Phase
S22 VSWR	1.9:1	2.0:1	SWR
S33 Imp	36+j24	90-j25.2	Ohms
S33 Rtn Loss	-10.1	-9.6	dB
S33 PHA	105.9	-21.1	Degrees
S33 VSWR	1.9:1	1.9:1	SWR
S31 Ins Loss	-3.7	-3.7	dB
S31 PHA	148.7	83.1	Degrees
S13 Ins Loss	-3.7	-3.6	dB
S13 PHA	149.1	83.3	Degrees
S32 Ins Loss	-4.2	-4.6	dB
S32 PHA	-61.3	169.6	Degrees
S23 Ins Loss	-4.2	-4.6	dB
S23 PHA	-61.4	170	Degrees

The measurements are as expected with a simple splitter.

The splitter was connected to dongles and the input impedance and measured as Port S11.
Impedance connected to the dongles:
S_{11} 978 MHz = 18.8 +j13.3 ohms
S_{11} 1090 MHz = 34.71 +j14.3 ohms

The above splitter above exhibited decreased performance when used with the 978 MHz antenna.

Based on testing performed to date, it appears the impedance matching between the dongles and the antennas plays a critical role in signal reception. With a dongle input impedance of approximately 25 Ohms to 30 Ohms, the data so far indicates an optimum antenna is the simple quarter wave vertical. The quarter wave vertical with a good ground plane (counterpoise) has a characteristic impedance of approximately 35 Ohms. However, with the high reactive component the antenna matching is susceptible to variations in the feedline lengths. The next step is to explore impedance matching option for the dongles to move them closer to a 50 Ohm resistive input and thus reduce the received signal variation due to phase cancellation within the antenna system. In addition, different splitter topologies should be explored to determine their effectiveness in a single antenna application.