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Passive Radar

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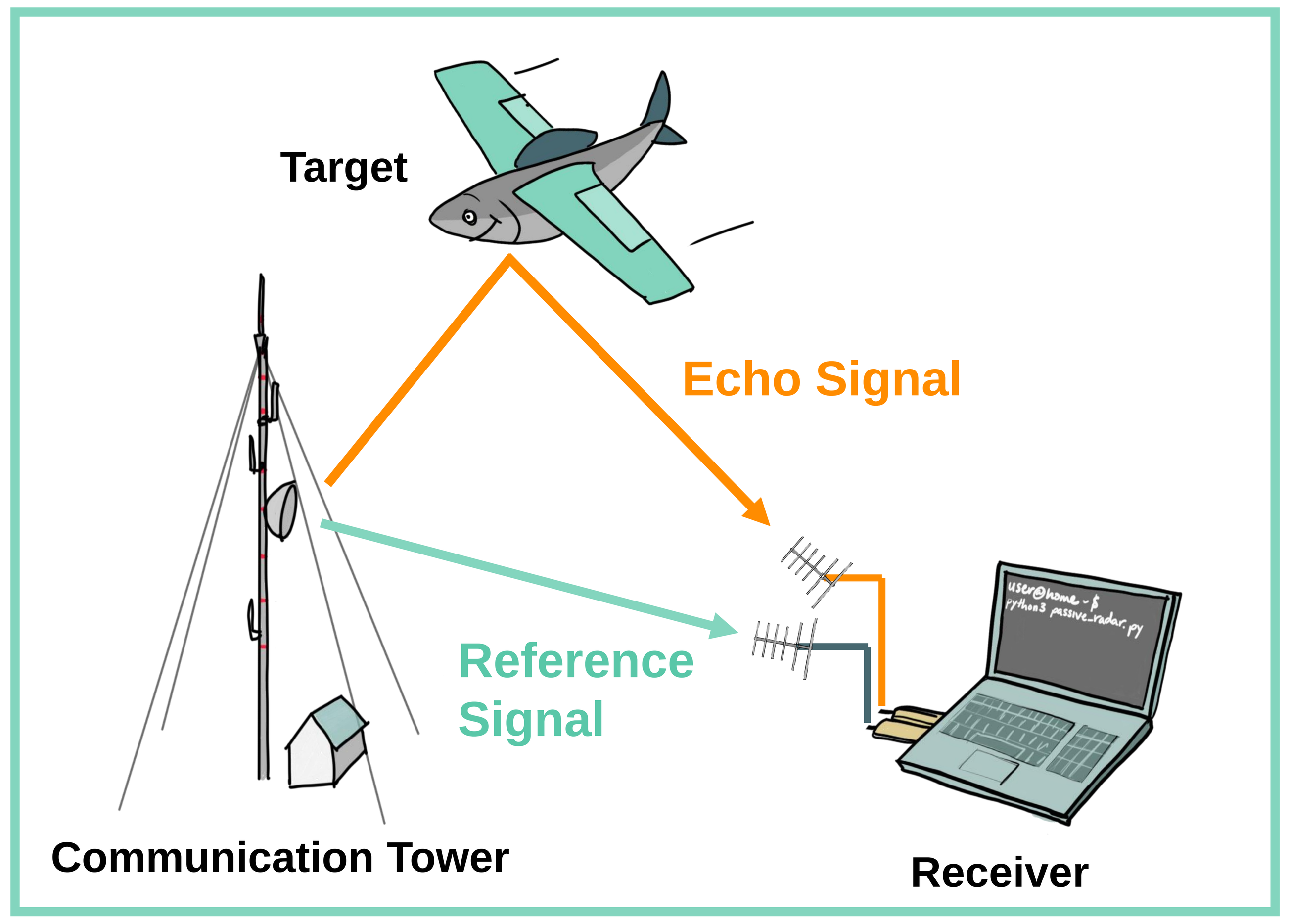
Introduction

Passive radar operates by detecting the echoes of communications signals as they bounce off targets such as airplanes or ships. Many different signals can be used, such as FM radio or TV broadcast[1].

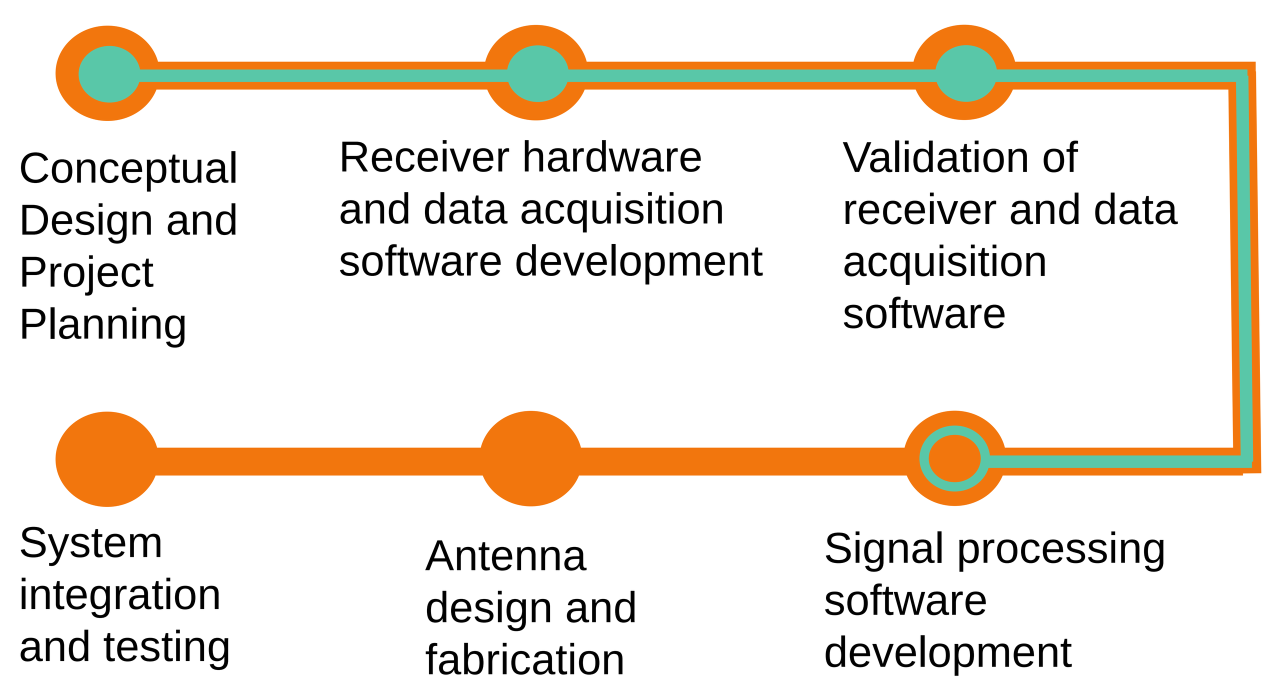


Passive radar has several advantages over conventional (active) radar. It is inexpensive and undetectable, and is not a source of interference.

Project Objectives

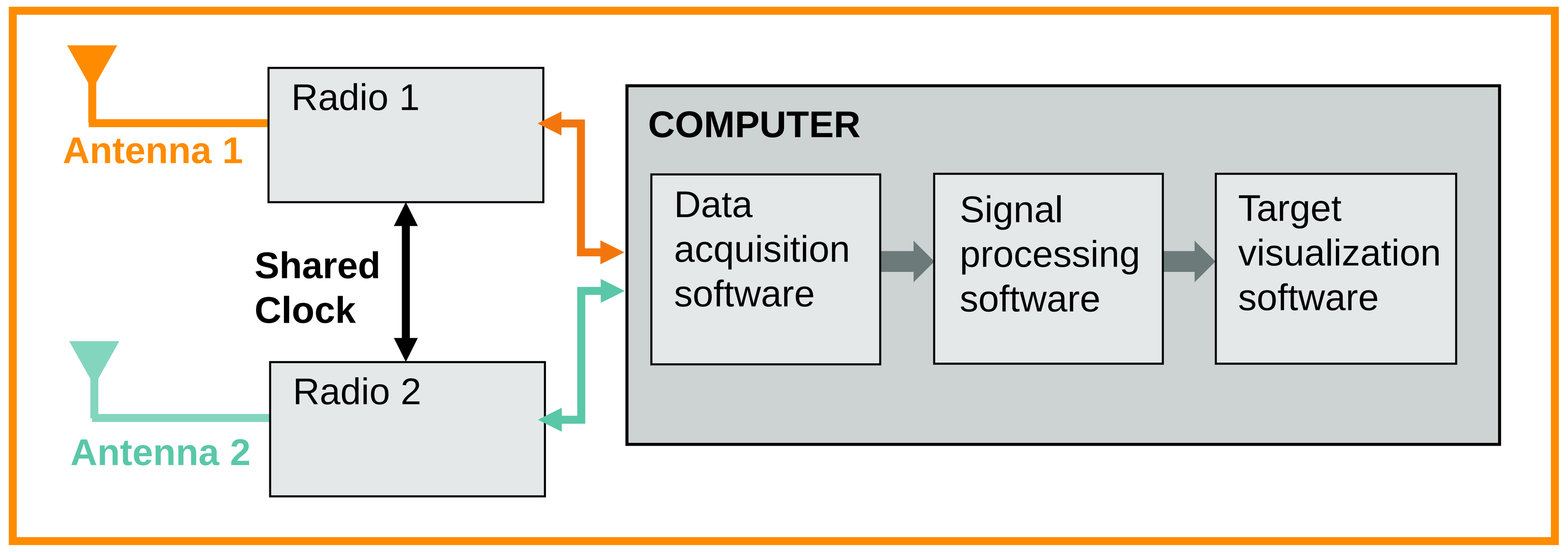
- Build a passive radar system that can detect airplanes.
- Test the system under different conditions to determine some of the challenges and limitations associated with using very low cost hardware for passive radar.
- Publish detailed documentation on system design and performance.

Design Process



System Architecture

Our design comprises two directional antennas, where one is oriented directly toward the signal source to receive the reference signal and the other points outward to receive the echo signal. The signals are digitized by two radio modules which share a clock source so that they are synchronized in time and in frequency. Next, signal processing algorithms are used to extract the weak echo signals from noise. The results are then displayed to the user.



Preliminary Results and Verification

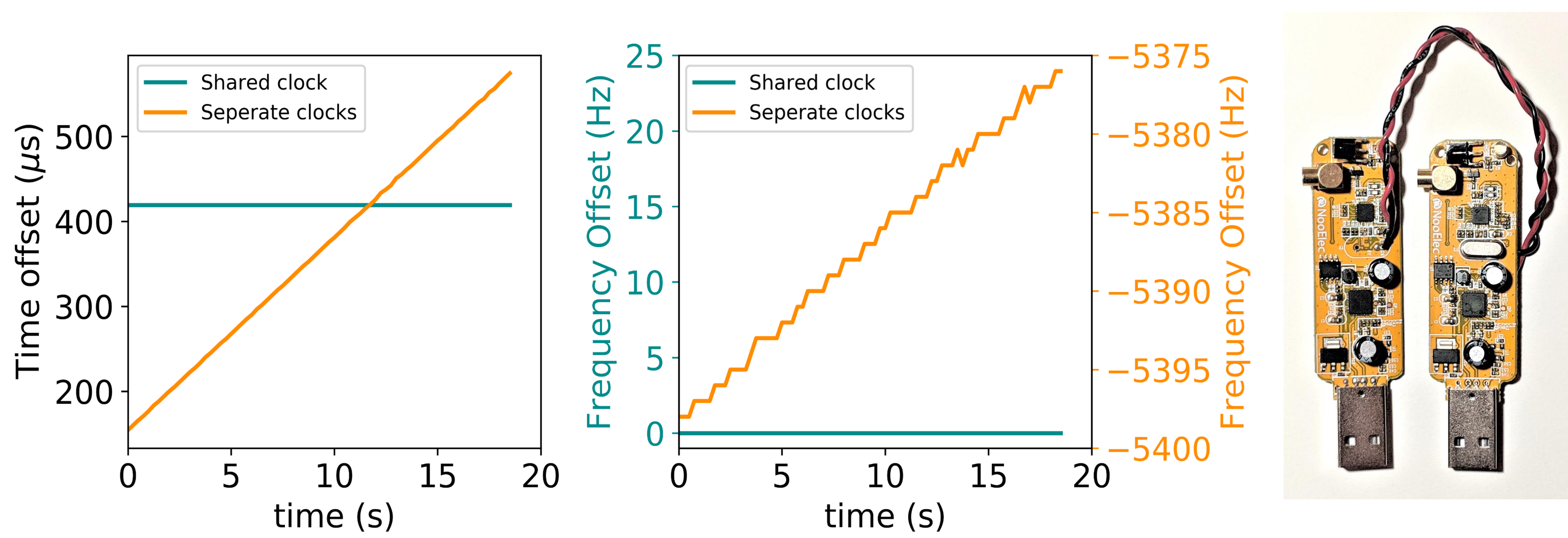
CLOCK SYNCHRONIZATION OF RTL-SDR DEVICES

To obtain synchronous receiver channels, we modified two extremely cheap software defined radios (RTL-SDR dongles) to share a single clock source following the procedure discovered by Juha Vierinen[2].

We then developed software to measure the time offset τ_o and the frequency offset f_o between the two receiver channels by simultaneously recording a signal on each channel and finding the peak of the cross-ambiguity function $\chi(\tau, f)$.

$$\chi(\tau, f) = \int s_1(t) s_2^*(t-\tau) e^{j2\pi f t} dt \qquad \tau_o, f_o = argmax(\chi(\tau, f))$$

Before connecting the receiver clocks, there was significant drift in both the time and frequency offsets. Sharing a clock eliminated the frequency offset and stabilized the time offset between the channels.



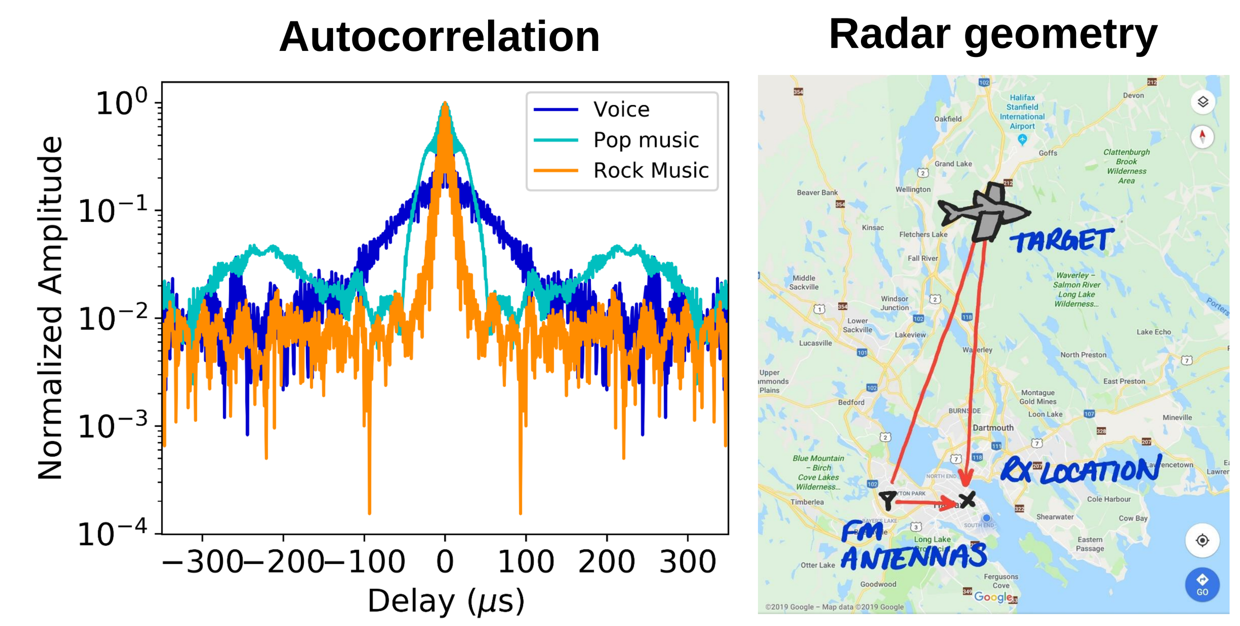
Assessment of Halifax area FM transmitters for passive radar

AUTOCORRELATION PROPERTIES

It is desirable for a signal used for passive radar to have a sharply peaked autocorrelation function so that it can be easily distinguished from delayed copies of itself. We found that FM stations broadcasting rock music have the best autocorrelation properties since they are closest to white noise.

TRANSMITTER LOCATIONS

Most of the high-power FM radio transmitters in Halifax are located on Washmill Lake Drive near Bayer's Lake. This offers a favourable geometry for our planned receiver location on Citadel hill.



Conclusions and Future Work

- We made a 2-channel coherent receiver by modifying RTL-SDR dongles.
- Analysis of local FM stations indicates that they are suitable for passive radar.
- In the next steps, we will proceed to develop an antenna system and signal processing software.

References

[1] Griffiths, Hugh D., and Christopher J. Baker. *An Introduction to Passive Radar*. Norwood, MA: Artech House, 2017.

[2] Vierinen, Juha. "$16 Dual-channel Coherent Digital Receiver." Kilpisjärvi Atmospheric Imaging Receiver Array. Accessed February 1, 2019. http://kaira.sgo.fi/2013/09/16-dual-channel-coherent-digital.html.