UAV-mounted GPR for remote area radioglaciology
Adrian McCallum
Background.....
A lightweight and affordable slope stability radar for avalanche detection in remote alpine communities
Radar Demonstration Kits Available from Quonset Microwave!

As the old saying goes, ask and you shall receive. Well hold on to your oscilloscopes Tin-Can fans! Quonset Microwave’s Radar Demonstration Kit is the first complete canenna radar kit to hit shelves and it looks awesome!

Quonset Microwave has put together three different bundles depending on your preference of options that are currently available for pre-order, with an initial ship date of August 2013. The base kit includes all the necessities: Radar Board, canennas (2), and the cabling kit. The other two kits build on this adding a tripod, mounting plate, and USB Battery Pack. To see how the kits and pricing break down check out Quonset Microwave’s website here: Link.

Operating at the International 2.4 GHz ISM Band, the Radar Demonstration Kit provides two interfaces for control: USB and Bluetooth. You read that correctly, Bluetooth! We expect to see some interesting projects utilizing that feature. There is also a filter prototyping area on the Radar Board for developing custom filters! We can’t wait to see what our Tin Can Radar Forum users can do with these kits!

Key Features of the Radar Demonstration Kit:

- Operates in the International 2.4 GHz ISM Band
- Output Frequency Range: 2.25 GHz to 2.5 GHz
- Control through USB and Bluetooth
  - Android application coming soon

- Available Radar Modes
  - CW (Continuous Wave)
  - FMCW (Frequency Modulated Continuous Wave)
  - Doppler
What is SDR?

**Software Defined Radio**

"a radio communication system where components that have been typically implemented in hardware (e.g. mixers, filters, amplifiers, modulators etc.) are instead implemented by means of software on a personal computer or embedded system."

(Wikipedia)
Typical makeup (SDR radio)?
A GNU Radio Based Software-Defined Radar

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Engineering

by

Lee K. Patton
Department of Electrical Engineering
Wright State University

2007
Wright State University
Ideal SDR system

Receive Signal Path

Transmit Signal Path
Field Programmable Gate Array

Increase system performance by reducing computational requirements

Currently realizable SDR (2007)

Translates Tx/Rx signal to/from carrier frequency
Universal Software Radio Peripheral (Ettus Research, LLC)
Weight: 1.2 kg

22 cm

0 - 3 GHz (fm Ettus) or designable

2 channels

Figures from Ettus Research LLC
USRP Motherboard with Tx & Rx daughterboards.
Technical Specifications:

- **Ideal Cameras**: J-sized 4K UHD, Canon 5D, Black Magic, Red Epic, etc.
- **RayLoad**: Ideal: 1kg to 8kg / max: 10kg (max and above depend on weight)
- **Speed**: - max: up to 70km/h (depends on payload) / Range: up to 1.5km
- **Flight Time**: - up to 30min (depending on payload, batteries, wind, weather, altitude)
- **Dimensions**: - diameter: 1000mm / width: 1500mm / height: 1400mm / weight: 4kg (plus battery)
- **Required**: Nothing, comes built, sealed and fully-ready-to-go. Just plug in the battery and fly!
Technical Specifications:

Ideal Cameras - large dSLRs, Canon 5D, Black Magic*, Red Epic* etc
Payload - ideal 1kg to 6kg / max 10kg (over and above drone weight)
Speed - zero up to 70km/h (depends on payload) / Range - up to 1.5km
Flight Time - up to 15min (depending on payload, batteries, props, weather, altitude etc)
Dimensions - diameter 1200mm / width 1100mm / height 415mm / weight 4.8kg (no battery)

Required: Nothing, comes built, tested and fully ready to go, just plug in the battery and fly!
Moya Quiroga et al. (2013) re. Mass Balance

"GPR and RES are impractical methods for [measuring glacier thickness & glacier volume] for remote and extensive glaciers."
Software Defined Radar: An Open Source Platform for Prototype GPR Development

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CSIRO Earth Science and Resource Engineering
International Symposium

Abstract: This paper presents an open source platform for software defined radar (SDR) development. The platform provides a flexible and modular framework for quick prototyping and testing of novel radar concepts. It aims to facilitate the development of new radar architectures and waveform design tools. The platform supports a range of features, including signal processing, waveform design, and data analysis. The software framework is designed to be easily extendible and customizable, allowing researchers to quickly prototype and test new radar configurations.

1. Introduction

Modern radar technology (GPR) has seen exponential growth in recent years, driven by advancements in signal processing, sensor miniaturization, and digital signal processing capabilities. The use of open-source software frameworks, such as GNU Radio, has been instrumental in facilitating rapid prototyping and experimentation in the field of radar research. This paper introduces an open-source platform for radar development, which aims to provide an accessible and flexible tool for researchers in the field of radar technology.

2. Implementation

The platform is based on a modular architecture that allows for easy integration of new components. It supports a range of signal processing algorithms, including time-domain, frequency-domain, and spatial-domain processing. The platform is designed to be highly customizable, allowing users to tailor the system to their specific needs.

3. Conclusion

The open-source platform for radar development presented in this paper offers a flexible and powerful tool for researchers in the field of radar technology. It provides a framework for quick prototyping and testing of novel radar concepts, allowing for rapid innovation and advancement in this field.

Future work in this area includes the integration of more advanced signal processing algorithms and the addition of new features to enhance the platform's capabilities.
Software Defined Radar: An Open Source Platform for Prototype GPR Development

Jonathon Ralston and Chad Hargrave
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CSIRO Earth Science and Resource Engineering
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Abstract—This discussion paper explores the potential of Software Defined Radio (SDR) technology to provide flexible and low-cost subsurface radar prototypes for the GPR community. Unlike traditional fixed hardware implementations, SDR uses software configurable RF modules which can be used to implement customized signal encoding, decoding and processing. However, the full potential of SDR has not yet been fully understood or exploited for radar-based applications, and so is of interest to the GPR community.

A major limitation is that it offers little or no provision to modify radar the operating characteristics according to the needs of a given application.

Further, most fixed-hardware radar systems also impose a number of important operational constraints which tend to limit the achievable sensing performance. These include:

1. Little or no knowledge of the actual transmitted signal
Components of a UAV-mounted SDR GPR system.....

UAV Payload capacity: 10 kg
SDR GPR Weight: ~2 kg (+ batteries)
Raspberry Pi
UAV Payload capacity: 10 kg
SDR GPR Weight: ~2 kg (+ batteries)
Advantages.....

1. Utilisation of available/optimal bandwidth in AO.
2. Radar can be dynamically tuned to optimise target detection, and
3. Software can be manipulated to accommodate spectrum of user expertise.
Limitations.....

Bandwidth (therefore range-resolution) due USRP architecture.

Three ways to increase:

1. Decrease bits per sample. 16 b/S is adequate.
2. Modify interface between USRP & PC. Current versions @ 50 MS/s in both directions, and
3. Modify FPGA firmware to allow stepped-frequency operation.

Approaching bandwidth of 100 MHz @ 16 b/s giving range resolution of ~1.5 m
All images courtesy Geoscanners (Sweden)
## Mechanical and Environmental Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Measurement</th>
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<tbody>
<tr>
<td>Dimensions LxWxD (mm/inches)</td>
<td>200x200x125 / 7.87x7.87x4.92</td>
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<tr>
<td>Weight (kg/pounds)</td>
<td>0.55 / 1.21</td>
</tr>
<tr>
<td>Weight compact radar (kg/pounds)</td>
<td>1.05 / 2.31</td>
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<tr>
<td>Fastening points LxW (mm/inches)</td>
<td>158x158 / 6.22x6.22</td>
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<tr>
<td>Ingress Protection</td>
<td>IP65</td>
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<tr>
<td>Operating Temperature (°C / °F)</td>
<td>from -25 up to +40 / from 14 up to 104</td>
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<tr>
<td>Relative Humidity (%)</td>
<td>99 (NC)</td>
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## Electrical Specifications

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<th>Specification</th>
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<tr>
<td>Antenna Type</td>
<td>Feed Loaded Bowtie</td>
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<tr>
<td>Shield Type</td>
<td>Top and Side Shield</td>
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<tr>
<td>Distance between the TX and RX (mm/inches)</td>
<td>98/3.86</td>
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<tr>
<td>Feed point impedance (Ohms)</td>
<td>328</td>
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<tr>
<td>Antenna Center frequency (MHz at 10dB BW)</td>
<td>550*</td>
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<tr>
<td>Survey Wheel Output Voltage (Volts)</td>
<td>5.01</td>
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*based on preliminary measurements

## Recommended Specifications

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<th>Specification</th>
<th>Requirement</th>
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<tr>
<td>Pulse repetition Frequency, PRF (kHz)</td>
<td>≥100</td>
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<tr>
<td>Scan Rate, Traces/Second</td>
<td>100</td>
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<tr>
<td>Range (ns), (depends on soil penetration)</td>
<td>15-50</td>
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<td>Low Pass Filter Cut-Off Frequency (MHz)</td>
<td>1000</td>
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<tr>
<td>High Pass Filter Cut-Off Frequency (MHz)</td>
<td>250</td>
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<tr>
<td>Gain</td>
<td>Adjust to 75% Swing</td>
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</table>
Conclusion

Development of a lightweight and flexible GPR system is increasingly feasible using SDR, however.

Remote sub-surface imaging of previously inaccessible areas (mountain glaciers, sea ice etc.) is already feasible using UAVs.
Acknowledgements

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Questions?