Evolution of the Software Defined Radio (SDR) for the Open Orbiter Project

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Overview
Software Defined Radios (SDRs) are an exciting development in radio technology. The SDR uses software to perform many of the tasks that only hardware could previously complete on a traditional analog radio. Such tasks include encoding/decoding or applying filters to reduce noise on the signal. This powerful fusion of software and hardware have allowed SDR to be smaller in size and have a greater functionality than traditional radio setups; a perfect solution for our Open Orbiter satellite.

Currently, the implementation we use consists of a simple $20 USB TV decoder for receiving, a Raspberry Pi micro-computer for transmis-
sion, and the open-source program GNU Radio for software decoding. Broadband FM transmissions and signals modulated with audio fre-
quency-shift keying (AFSK) have been received and decoded successfully. In addition, ongoing experimentation for receiving satellite communications are yielding promising results.

About OpenOrbiter
OpenOrbiter is a program at the University of North Dakota that is working to create designs for a complete CubeSat-class spacecraft that can be fabricated from low-cost commercial off-the-shelf (COTS) parts. As a student project, it seeks to attain education goals (defined by student expectations survey results¹), in addition to the technical development ones. As the development and testing program for the Open Prototype for Educational NanoSats (OPEN), OpenOrbiter is developing and testing designs that can be used by educators and researchers worldwide to build a spacecraft that can be built with a parts cost of under $5,000 USD². This enables new missions for educators and researchers (particularly in developing countries where it could be integral in launching a space program⁴) that might not otherwise be possible.

Goals of SDR Development
The SDR project aims to create a low-cost method for transmitting from the spacecraft to and from the Earth-based ground station. Specific objectives include:
- Antenna design (for both ground and spacecraft)
- Testing of the SDR unit for receiving purposes
- Decoding the analog signals received by the SDR
- Configuration of the Raspberry Pi as a possible transmitter
- Supporting common protocols (CCSOS, GPSR, ADSB, etc.)

Work on SDR To-Date
Current work has included configuring the SDR receiver unit (shown in Figure 2) with a laptop for testing (shown in Figure 1) and the configuration of GNU Radio (shown in Figure 5) to support the receiver. The present GNU configuration contains several software filters (Low Pass and Squelch) with full customization to allow for various frequencies and bandwidths (shown in Figure 5). Demodulations of the AFSK signal are currently being handled by a 3 particle application; this will change soon as our current goal is to develop a software radio within GNU Radio as well as adding support for addition demodulation systems.

Work on the transmitter is ongoing. The initial USB SDR that had been indicated by some reports to support transmission was determined not to possess this capability. Current work, thus, focuses on other transmitter designs, with the main focus being the Raspberry Pi. Through the use of Fiji and Minimodem, several open-source applica-
tions, we have been able to achieve short-range, high-quality data transmission (see Figure 6). Currently, goals for the transmitter are research into better antenna and filter designs, as this will allow for the long-range communications needed while preventing the transmission from encroaching on other frequencies. In addition, a long-term goal is for complete transmitting integration with GNU Radio.

Outcomes of Current Work-to-Date
The USB SDR setup was demonstrated via capturing a signal from the NOAA 18 satellite. Figure 7 is a picture of the GNU radio software when NOAA 18 passed over North Dakota and a slight signal was picked up using the small antenna. Recently, the SDR receiver was able to isolate data transmitted from the Raspberry Pi within the radio spectrum and demodulate that data. Figure 6 shows the filtered reception of the AFSK signal with GNU Radio. Development on SDR units for orbital and aerial craft is ongoing.

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References
2. Straub, J. J. Berk, A. Nervold and D. Whalen. 2013. OpenOrbiter: An Interdiscipli-


craft Program for Interdisciplinary Education. The Proceedings of the AIAA Space 2013 Conference.

ings of the 2013 IEEE Aerospace Conference.
7. Straub, J., J. Berk, A. Nervold, J. C. Berk. 2013. Application of Collaborative Au-

tonomous Control and the Open Prototype for Educational NanoSats Framework to Enable Orbital Capabilities for Developing Nations. Proceedings of the 64th International Astronautical Congress.
8. Wegerson, M., J. Straub, S. Noghanian. 2013. Work on a Software Defined Ra-

dio (SDR) for a CubeSat-Class Spacecraft. Presented at the 2nd Annual North Dakota Space Robotics Forum.