Using Bluetooth Radios to Communicate with Acoustic Instruments

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Abstract
This extended abstract describes some advantages and limitations of using Bluetooth® (BT) radios as a serial cable replacement between acoustic instruments and a laptop computer. BT radios are a relatively inexpensive method to communicate wirelessly with one or more acoustic instruments. A case study is presented where this technology was implemented to allow project personnel to check battery voltage, system status, and real-time flowrate and stage readings from 3 Sontek/YSI Argonaut-SW flowmeters. An application of integrating GPS data into a Teledyne/RD Instruments Streampro datafile using a wireless RS-232 serial communications is also summarized.

DISCLAIMER - The use of trade names is for informational purposes only and does not constitute endorsement by the Bureau of Reclamation.

Introduction
In recent years, wireless technology has rapidly changed how we communicate and transmit data. Likewise, wireless communications has created numerous alternative methods for collecting field data. Wireless communications can simplify and improve the efficiency of data collection in the laboratory or the field. Wireless communication transmitters can range from close-in (30 ft using BT) to satellite systems that have nearly complete global coverage. While the potential applications for this technology are many, in this short paper I will focus on BT systems that can replace RS-232 serial communication cables and how they can be used with a couple of common acoustic instruments.

Equipment and Setup
On a recent project, I needed to check the status of an acoustic flowmeter without having to slog through a mosquito infested wetland to check the battery voltage or to download data. I found an inexpensive wireless solution that was described as a wireless RS-232 serial cable replacement. The equipment I purchased (for under $200) was a BT radio pair that was used to create a BT (virtual) serial port profile on a laptop computer that can be used to talk to a second transceiver attached to the flowmeter's RS-232 connector (see figure 1). This system can be used in two modes: (1) Using a pair of

radios that utilize RS-232 connections with DB9 connectors and is powered by a 4 to 9VDC battery or (2) use a BT radio connected to and powered by the computer's USB port instead of the computer's serial port radio. Using the USB powered radio is advantageous because it eliminates the need for a separate battery or power supply.

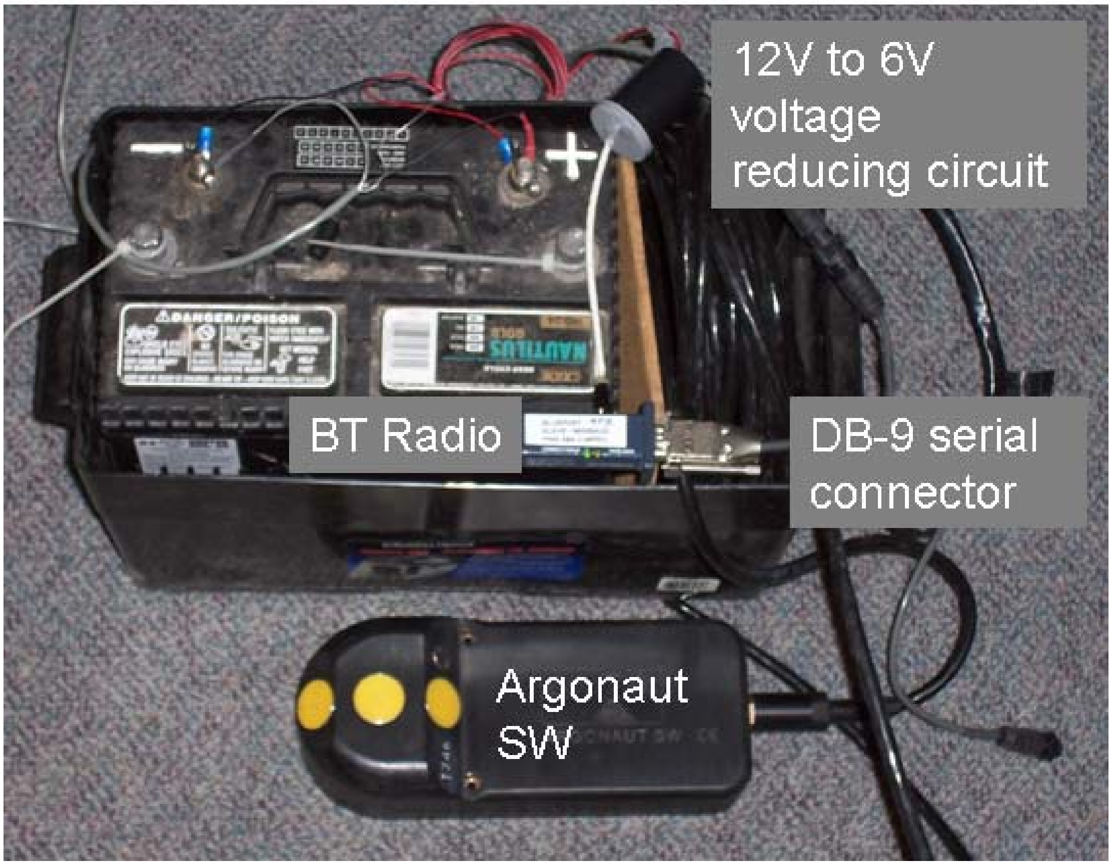

Figure 1. Photograph of Argonaut SW flowmeter, 12V battery, voltage reducing circuit, and the serial connector attached to the BT radio.

Bluetooth Basics - BT wireless technology operates at 2.45 GHz which is a license-free ISM (industry, scientific, medical) frequency band. To avoid interference with other devices operating in this frequency band, BT divides the bandwidth into 79 channels and switches channels up to 1600 times per second. BT serial port adapters can be used with personal digital assistants (PDAs), computers, notebooks, and smart phones that support the BT Serial Port Profile (SPP) and BT Generic Access Profile (GAP). While not discussed in this paper, this wireless serial port technology is well suited for use in applications where a PDA or laptop communicates with another serial device (RTUs, PLCs, water level sensor, or datalogger). Furthermore, using a USB powered radio(s) on a laptop keeps the increasingly rare serial port available for other devices or a second set of radios to form a multipoint network (or piconet).

When using BT radios in either mode, the radio pairs are easy to setup for baud rates of 9600 and 115,000 bps (the factory default). But they are **not** plug-n-play. These radios require a basic understanding of radio transmission and RS-232 communications. Since the BT radio uses RS-232 protocols, you first configure the “master” BT device so it connects to a BT “slave.” Dip switches are used to set the master or slave configuration. Depending on the serial devices used (it depends on which side of the link you are on, the Data Terminal Equipment (DTE) side or the Data Communication Equipment (DCE) side) it may be necessary to change some internal jumpers to make a serial connection. The next step is to configure the RS-232 interface to match the settings of the device you want to “talk” to. For example, you must match the baud rate, parity, data and stop bits, and hardware flow control. The two default baud rates are changed using dip switches. Atypical baud rates such as 4800 or 19,200 require re-configuring the radio firmware using an ASCII terminal such as Microsoft’s® Hyper-Terminal. Local configuration took several attempts because the connection procedure was intermittently successful. A solid understanding of serial communications is required to make the proper connections for unusual setups or if you need to take advantage of several power saving settings or security options such as a unique PIN. The firmware can also be changed to create a user specified device name (e.g. FLOW01).

Sontek Argonaut-SW Case Study

As previously mentioned, I used a master BT radio to communicate with three slave BT radios attached to 3 acoustic flowmeters. For this case study, I was using three Sontek/YSI Argonaut-SW flowmeters in 3 culverts in an irrigation canal. I wanted the project technician servicing the flowmeters to be able to check the 12V deep-cycle battery status on a weekly schedule. I provided the technician with 1 master radio for his laptop and 3 slave radios for the flowmeters. At each flowmeter location he could use HyperTerminal or the manufacturer’s terminal program (SonTerm) to check the battery voltage from inside the truck. (This setup could also be used to download the data recorder, but this is painfully slow at 9600 baud which Sontek’s software requires!) When done, the technician could drive to the next site and repeat the procedure. Checking the battery voltage was easily accomplished but it was important to program the flowmeter to output an ASCII data (not binary) to the serial port. The technician could wait for the next data transmission, in this case, once every 5 minutes or he could poll the device by sending the letter “o” to the flowmeter and the flowmeter would send the last data string.

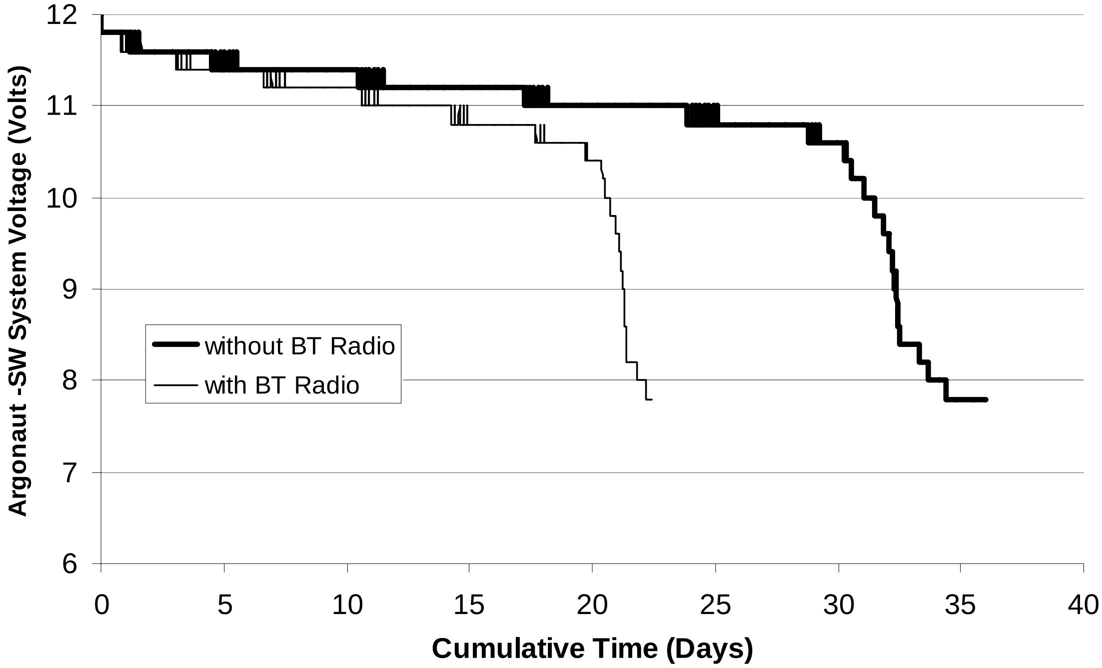

Figure 2. Comparison plot of Argonaut-SW system voltage versus days of continuous flowmeter operation with and without a BT radio.

Power Requirements

Each BT Radio is powered using 4 to 9VDC. The BT radio draws 30 to 50ma (dependent on data rate) when transmitting or receiving data. While in standby mode the radio draws about 2ma. For myself and all you non-electrical types, I performed a simple bench test to determine the charge life for an inexpensive 80 amp-hr, deep-cycle marine battery while operating the flowmeter with and without a BT radio. The flowmeter was set up for 100 percent duty cycle and the BT radio transmitted a serial string every 5 minutes. For data collection with and without the BT radio the flowmeter stopped working after 22. 5 and 36.9 days, respectively (see figure 2).

It is important to note that the system voltage reported by the flowmeter was consistently 0.5V lower than the voltage measured using a voltmeter. Another important detail is that the BT radio operates using 4 to 9VDC and it requires a separate battery or a voltage reducing circuit to use the 12V battery powering the flowmeter. Figure 1 shows a photograph of the flowmeter configuration used for the bench test. As previously mentioned, these radios have power saving features, such as sleep and sniffer modes that can be used to reduce power consumption.

TRDI Streampro Application

Another application is to include GPS NMEA strings into Teledyne/RD Instruments Streampro data files. The Streampro is an acoustic Doppler profiling instrument that can be used to measure discharge in shallow channels. The currently available model does not include an integral GPS receiver, as a result, it cannot store GPS data in its data file (unlike its cousin the WH Rio Grande). Integrating GPS data into the Streampro data file would be beneficial when collecting velocity profile data at various locations that may not be easily accessible by wading. For example, the Streampro can be used to collect habitat data (depth, velocity, and temperature) for an endangered fish species and GPS data would help document where data were collected.

The release of WinRiver II software allows the Streampro to be configured to operate using a laptop computer with a BT radio instead of using the typical BT enabled pocket PC. This software also allows for other devices to be added, such as a depth sounder or an external heading device. For this application, only GPS data collection will be addressed. The first step involves changing the firmware to transmit data at 4800 baud, the only baud rate supported by my hand-held GPS. This required establishing a connection to the BT radio(s) using HyperTerminal and sending a command to change the baud rate. When the GPS serial radios were configured, I connected a BT USB adapter into a USB on my laptop. Windows XP® found the new hardware. I went into the Add Bluetooth Devices Wizard and added the Streampro. You may or may not be prompted for a device passkey. If prompted, I found that selecting the "Use passkey found in the documentation" and entering a zero as the passkey worked. The Streampro was added to the list of available BT devices on the laptop. The laptop will then report an outgoing and incoming COM ports, e.g. COM3 and COM4, respectively. Use the outgoing COM port when setting up the communication settings in WinRiver II. Once the Wizard is finished the Streampro (passkey enabled) will be shown in the BT Devices window.

The next step is to configure WinRiver II to make a Streampro measurement by selecting the Streampro 2000 kHz as the ADCP and checking the GPS device. The next step is to configure the serial communications for the ADCP and GPS devices. If the GPS Device check box is not available (grayed out) you will need to get the latest version of WinRiver II (v1.02) which corrected this problem. I used the built-in COM port (COM1 at 4800 baud) on my laptop for GPS data and the outgoing BT serial port (COM3 at 115k baud) for Streampro data. From this point forward the configuration is very similar to a typical TRDI Rio Grande application.

When a Streampro measurement is initiated the blue LED on the Streampro's electronic housing should turn on and will blink for each acoustic ping. GPS data should be visible in the Composite Tabular window or can be viewed in a GPS tabular window.

This setup will allow the user to incorporate GPS data into the raw ADCP data file and can also save a text file of the GPS NMEA string data which contains useful information about number of satellites, time and date, speed, heading, HDOP, etc.

Limitations

Both Sontek and RD Instruments equipment use a “break” signal to wakeup the instrument or interrupt data collection. Both manufacturers have a soft break command which must be used with wireless serial communications. The soft break commands for Sontek and RD Instruments equipment are +++ and ===, respectively. While I was able to get the Sontek to receive a soft break command (for 9600 baud only), I was not able to get a 300 kHz Workhorse or a 1200 kHz Rio Grande to accept a soft break.

It is important to note that GPS information is not sufficient to convert ADCP velocities into geo-referenced (earth coordinates) because the Streampro is not currently equipped with a compass. A compass is needed to transform ADCP referenced velocities into earth coordinates.

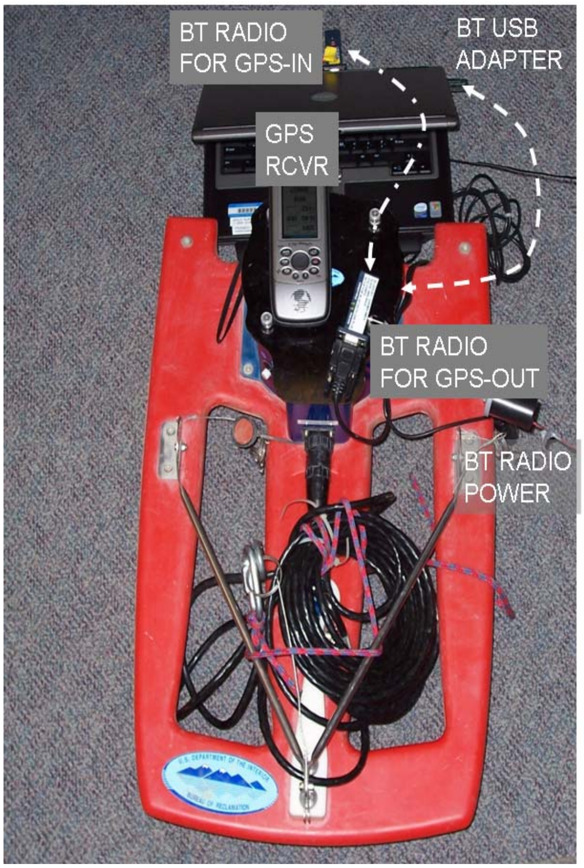

Figure 3. Photograph of GPS "integrated" Streampro. While the laptop appears to be wired to the Streampro, GPS and ADCP data are wirelessly transmitted to the laptop running WinRiver II (v1.02).