Environmental Monitoring: Guide to Selecting Wireless Communication Solutions

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Rapidly growing demands for information and increased productivity in the environmental monitoring field have been met with a whirlwind of wireless communication options that can be integrated into data collection systems, with cellular, radio and satellite telemetry solutions leading the way. With so many options available, it is important to understand the features, advantages and limitations of each in order to select the optimal solution for a given data collection system.

The Options

Essentially, wireless communication options are simple. They include a modem that provides a defined radio frequency (RF) and an antenna. However, radio waves or signals exhibit very different propagation characteristics depending on their frequency band, so engineers must take into consideration these characteristics when designing a wireless system.

The complication comes with the numerous types of communication modems built to capture these signals. These modems and their respective frequency bands include:

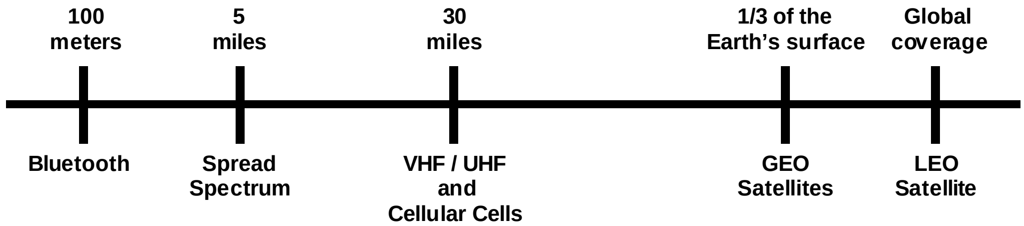
- Very High Frequency (VHF) - 30 to 300 MHz
- Ultra High Frequency (UHF) - 300 to 1,000 MHz
- Cellular – handset / modems: 824.01 to 848.97 MHz; cell towers: 869.01 to 893.97 MHz
- Spread Spectrum - 902 to 928 MHz and 2,400 to 2,483.5
- Bluetooth –2400 to 2483.5 MHz
- LEO (ORBCOMM) satellite - uplink: 148 to 150.05 MHz; downlink: 137 to 138 MHz
- GOES Geostationary satellite – uplink: 401.7010 to 402.0985 MHz; downlink: 1600 MHz

Factors to Consider

In addition to frequency band and modem output power, there are other factors to consider, which influence the optimal range of communication. One is “Line of Sight” which means one antenna must “see” the other, without obstructions. Line of sight is not mandatory, but when available, greatly improves performance and range. This is especially true with higher radio frequencies where signal strength is reduced from obstructions such as walls, trees, foliage and concrete and eliminated with metal objects or structures.

Positioning, gain, antenna tuning, atmospheric conditions, time of day, ambient frequency, noise, and terrain are also all important variables affecting RF signal and communication range.

Typical maximum point-to-point transmission range
of respective telemetry modem type



VHF and UHF Radio Communications

Because of the flexibility and range (typically good for up to 30 miles) VHF / UHF systems are often used in environmental monitoring applications involving gate or pump control, and with SCADA [supervisory control and data acquisition] systems. Frequency bands are typically 66 - 79 MHz; 132 -174 MHz; 216 -266 MHz; 380 - 512 MHz and 928 - 960 MHz.

It is important to carefully evaluate the condition of the remote site when configuring a VHF / UHF system. Typically an engineering firm performs a radio propagation study to determine the best configuration and whether additional repeater sites are required. Such additions could greatly increase the costs.

VHF / UHF telemetry systems also incur licensing costs from regulatory authorities such as the FCC.[1] However, since the user is assigned a specific frequency, interference from other radios is low. In addition, users have control over their data and can define the frequency of interrogation and transmissions. Data packets are typically sent with transmission confirmation and are error-check and corrected. The configuration of the data packets is either done by the data logger or by a smart packet radio.

Cellular Telemetry

Originally designed for voice communication, the cellular infrastructure uses a network of base stations and antennas, called a “cell” to cover a large area. Cell sizes range from sixth tenths of a mile to 30 miles (1km to 50km) in radius. The Global System for Mobile Communications is growing in the United States and uses much smaller cells, fewer than 6 miles (10km) across.

Cellular telemetry in environmental monitoring applications works well in areas with strong and reliable cell coverage. Although cellular coverage is increasing, there are still many remote areas where it is not available or the signal is weak. Also, because the cellular infrastructure uses a control channel to send packets of data, cellular voice coverage does not always equate to quality data coverage. Therefore, it is critical to ensure quality data service is available before choosing this option.

Circuit switched data services are billed by time and are suitable where infrequent connection is needed and large data files are transferred. Packet data service is suitable

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[1] To control RF interference in the United States, the Federal Communications Commission (FCC) regulates all frequency bands. Accordingly, certain radio frequencies require environmental monitoring station users to obtain a license directly from the FCC.

for data collection or alarming applications because small amounts of data are involved and remote systems often monitor continuously.

Spread Spectrum Radio Communications

The FCC has allocated some specific frequency bands for flexibility. Called Spread Spectrum, these bands have two primary advantages: they are unlicensed and free.

Spread Spectrum involves two coding techniques: Direct Sequence or Frequency Hopping. Direct Sequence enables digital radio transmission on multiple radio channels. Frequency Hopping concentrates the radio power on one narrow channel at a time for a very short duration and typically are better in environmental monitoring applications where a strong penetrating radio signal is more important than high data rates.

The 900MHz band allows for a better radio propagation and penetration properties than 2.4GHz, however the 2.4GHz band is designed for much higher data rates. Bluetooth and Wi-Fi communications use the 2.4GHz band. For environmental monitoring applications, where the amount of data transmitted is small and the radio paths are not congested, the 900MHz band gives better performance.

A Spread Spectrum system is more easily set up than a VHF / UHF systems and a site radio propagation study is usually not required. However, because these bands are free, signals may be heavily polluted by other unlicensed systems and may degrade signal integrity and range.

Bluetooth Radio Communications

A relatively new radio protocol increasingly being used in environmental monitoring applications, Bluetooth is a low-cost, low-power, short-range radio link between mobile PCs, PDAs, mobile phones, and electronic instruments. This simple two-way radio solution allows different electronic instruments to “talk” to each other without cables or infrared.

When combined with data loggers through an RS232/RS485 Bluetooth serial port adapter with an external antenna, Bluetooth technology offers many other advantages. It eliminates the need to open enclosures that house the data logger, in order to establish communications. It can be used to collect data from a remote site or be employed as the link from the data collection platform to a nearby telemetry modem whose location is better positioned for RF performance. In monitoring applications, data logger communications also can be established without users leaving their vehicles.

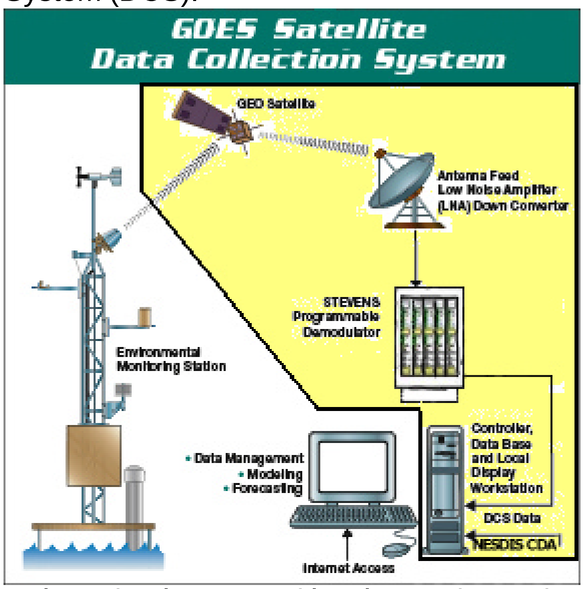
One example is the Stevens Water Monitoring System’s class 1 RS232 Bluetooth adapter that enables a wireless links between the any data logger with a serial port and another Bluetooth enabled computer, PDA, telemetry modem or device.

Satellite Telemetry

Bouncing an RF signal off a satellite is one of the best options for remote installations, especially in locations where no other reliable RF or telephone coverage is available, or the infrastructure cost, such as using repeaters, is not economically feasible. There are two primary satellite systems that offer remote environmental monitoring applications: Geosynchronous Earth Orbit (GEO) and Low-Earth Orbit (LEO).

GEO satellites are positioned at a fixed point approximately 22,000 miles (36,000 kilometers) above the earth's equator. This height matches the earth's rotation speed and allows the satellites a full-disc view at a stationary position. They are primarily used for weather imagery to enhance forecasting.

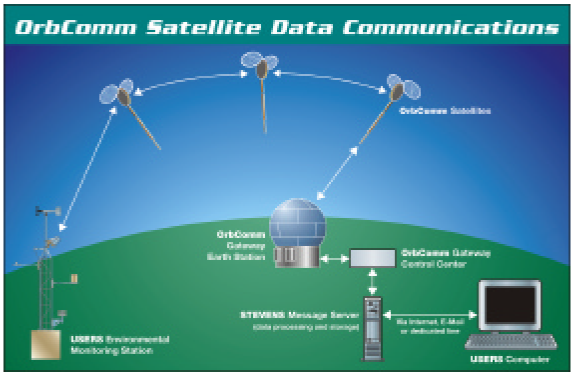
The United States normally operates two GEO meteorological satellites, named GOES (Geostationary Operational Environmental Satellite) West and GOES East. In addition to weather imagery, these satellites include instrumentation used in environmental monitoring communication via a relay system, known as the GOES Data Collection System (DCS).



Only Federal, state and local agencies and government sponsored environmental monitoring applications can apply to NOAA / NESDIS for permission to use the GOES DCS. Although the DCS is a one-way transmission and offers no transmission verification and no retransmission of missed data, the data transmissions are very reliable and data is easily shared among government users.

LEO satellites typically orbit about 400 to 800 miles above the Earth's surface and orbit a local horizon in approximately 20 minutes. The orbiting periods range from 90 minutes to two hours, at approximately 17,000 mph. LEO systems use a satellite-to-satellite hand-off to maintain communications and are best for short, narrowband communications

ORBCOMM, a leading LEO system used in environmental monitoring applications, provides global coverage with 30 satellites, and is capable of sending and receiving two-way data packets anywhere in the world. It verifies data transmission to minimize the risk of missing data. Unlike GEO satellites, most LEO satellite systems are commercial ventures; therefore, the data is proprietary



Subscriber communicators pass data messages to and from Gateway Control Centers (GCC) over ORBCOMM satellites. GCCs then route messages to third party services such as one operated by Stevens, who then deliver the data message to users via Internet, e-mail or dedicated delivery lines. Since the lifespan of a LEO satellite is five to eight years, another important consideration for long-term users is the satellite maintenance and replacement plan the LEO provider offers.

Final considerations

One other factor to consider is ongoing costs. Of the various telemetry options, only cellular and LEO satellite systems involve a communication fee based on time or data transmission or both. Fees range from $30 to $70 per month. GOES Satellite, VHF, UHF, Spread Spectrum, and Bluetooth communications do not incur monthly fees.

With information about the options at hand, only a few steps need to be taken to choose a system: evaluate the water monitoring application; outline data collection needs, making sure to include expansion expectations; and consider costs.

About the Author:

Scott South has been actively involved in the water industry for more than 10 years. Since 1998 he has been CEO of Stevens Water Monitoring Systems, Inc., a pioneer in providing advanced water-monitoring information. He is also co-founder of Stormwater Management Inc. For more information call 1-800-452-5272 or visit www.stevenswater.com.