

Update on efforts toward a new ALERT protocol

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At the National Hydrologic Warning Council meeting in San Diego in May of 1999, Chris Roark of Pacific Systems and Don Van Wie of DIAD Inc. presented a paper that suggested that higher data rates were now feasible for ALERT, and that work should begin on defining a new ALERT protocol that could be economically phased in alongside the present protocol.

A panel discussion was held at the May 2000 ALERT Users Group meeting in Monterey to present and discuss varying views on how and whether work on a new ALERT protocol should go forward. Panel members included Robert Burnash, widely known for his career-long contributions to the ALERT community, technical representatives of three ALERT manufacturers (Rick Lockyer of Handar, Joe Johnson of Hydrolynx, and Jim Slouber of High Sierra Electronics), and the authors of the paper, Roark and Van Wie. The discussion was moderated by Kevin Stewart.

Proponents of modifying the ALERT protocol argue that basic improvements are needed, such as:

- recognizing and correcting errors in transmitted data,
- increasing the capacity of the data field to permit improved range and resolution,
- enlarging the sensor field to permit assignment of unique IDs and reduce confusion resulting from ID reuse.

The authors pointed out that many other enhancements are also possible, depending upon the needs and wishes of the ALERT community. However, all enhancements to the ALERT protocol involve sending more information in a message, and increasing the length of a message will only cause more contention and data loss in channels that are already near capacity. Therefore, increasing the data rate of an ALERT message is a prerequisite to any meaningful improvements in the ALERT protocol.

The panel discussion aired a variety of views on the both the advantages and risks of making changes to the protocol. There was consensus on the need to protect the investment in existing systems, preserve the strengths of event-based, real-time data collection, and keep the system simple. There was also general agreement that discussion about the format of a new protocol is premature until it has been demonstrated that increases in the data rate could be achieved. The increased data rate would need to be achieved within the narrowbanding requirement, and work under field conditions applicable to existing ALERT equipment. In particular, questions were raised whether a higher baud rate could be supported in situations where ALERT transmitters operate over indirect and/or multiple paths. There was a general agreement that the first order of business should be a field trial to demonstrate the feasibility of moving data at higher rates in difficult RF environments.

A feasibility trial

At the end of May 2000, Roark and Van Wie performed a simple technical feasibility trial using a pair of Integra TR DataRadios®. The Integra was selected because it is representative of the proposed technology, it is commercially available, and it allows the direct input of serial data via standard RS-232 cable and connector. It transmits and receives data at rates of 4800 or 9600 baud in a 12.5 kHz (narrowband) channel, or 19,200 baud in a 25 kHz channel. The Integra uses a proprietary derivative of the Gaussian Minimal Shift Keying (GMSK) scheme proposed in the Roark and Van Wie paper. It is called Differential Raised Cosine Minimal Shift Keying (DRC-MSK), and differs in that the characteristic curve of the time-domain filter is cosine squared rather than Gaussian. The data are differentially coded. Although this unit would not necessarily be the choice of ALERT manufacturers, it is a readily available representative of the technology we needed to test.

The Integra radios were available only briefly, so we could not implement a long-term study that would conclusively determine the suitability of this technique across a wide variety of environmental conditions. We therefore sought to do a simple feasibility study, or elimination trial. The purpose was to determine if data could be moved at increased rates over paths that are poor or marginal for existing ALERT equipment.

We thank EFJohnson Data Telemetry Corp. and its representative, Bill Novak, for making the Integra radios available on an evaluation basis. The tests were performed using base station equipment at DIAD Inc. headquarters in Longmont, Colorado. The test utilized existing ALERT sites owned by Boulder County, Colorado, and spare ALERT equipment belonging to the Urban Drainage and Flood Control District. A solid-state antenna switch was provided by High Sierra Electronics, and support for the setup of the NovaLynx 5096 was provided by HydroLynx Inc. Time and materials for the study were donated by Pacific Systems Consulting and DIAD Inc.

Test setup

Two test sites were selected; neither had a direct path to the base station.

- Site One: This site is at 826 3rd Ave in the town of Lyons. It has a 3 Db gain omni antenna at 20 ft AGL and is sheltered in the direction of the receiver by a nearby 400-foot hill. The line-of-sight distance to the base is 13.6 miles. Computer modeling of the path losses showed that the received signal strength would be in the range of -95 dBm, and that the data might be received, but would be marginal.
- Site Two: The second path was from the valve house at the base of Buttonrock Dam on the North Saint Vrain River. This existing ALERT site was selected by monitoring the repeater input channel at the base station, and examining the record over several days for sites that were received only some of the time. The computer model for this path shows an expected received signal strength of -115 dBm; the transmitter is at the bottom of a twisting 800 foot canyon and is relying on multiple reflections of the signal to reach the base station, 18.4 miles away.

The test setup used a NovaLynx 5096 ALERT transmitter. The serial output of the 5096 is a 35 byte ASCII encoded message that includes a formatted time stamp, sensor ID and data value. This output, at 9600 baud, was fed to the Integra TR. The message was buffered and transmitted at the baud rate selected for the test. The Integra was tuned to a deviation of 2.5 kHz operating within a 12.5 kHz bandwidth. The same 5096 was used

to transmit ALERT messages using a Maxon digital transmitter with an output power of 4.1 watts and 2.5 kHz deviation. All tests were performed at 169.500 MHz.

The Integra transmission preamble was set to 40 msec at Site One and 80 msec at site two. At 4800 baud, the total transmission time for 35 bytes is less than 75 msec, so the total transmission times for the Integra varied between 115 and 155msec. For the standard ALERT transmissions, 4 bytes were sent at 300 baud preceded by a 250 msec preamble, for a total transmission time of about 385 msec per message.

The 5096 was outfitted with an antenna switch so that the Integra signal would pass in the normally closed mode, and the power for the 5096 transmitter would switch the antenna to pass the ALERT output. This configuration was chosen to allow fully side-by-side testing of each transmission over the same antenna and cable configuration. Unfortunately, while this configuration appeared to work on the bench, all tests greater than ¼ mile away with the Integra failed. We determined that the ALERT radio was powering up, and therefore activating the antenna switch, before the Integra transmission had completed. The local operation appeared successful only because of the stray radiation from the blocked transmitter.

The tests were performed a second time using the same apparatus without the antenna switch. At each site, the tests were performed using the same cable and antenna, first in the ALERT mode, then with the Integra. Transmissions were triggered by the 5096 at regular intervals. At the receiving end, the same roof mounted DB-224 antenna and cable were used to simultaneously feed the signal to a Ritron DR200 receiver with a HSE Model 1000 ALERT decoder, and to an Integra receiver set to a carrier sense of -105 dBm. The ALERT receiver had a sensitivity of -114 dBm at 12 dB Sinad.

Results

From Site One, transmissions were sent at 1-minute intervals. We received 49 out of 50 ALERT transmissions, indicating the path was solid, even though indirect. From the Integra:

- we received 35 of 35 transmissions sent at 4800 baud with a 5 watt power.
- We transmitted at 4800 baud with the output power reduced to 2.5 watts, and received 40 out of 40 transmissions. A second study at 2.5 watts resulted in receiving of 21 of 24 transmissions for a total success of 61/64.
- We increased the baud rate to 9600 and received 10 out of 10 messages transmitted at 5 watts.
- We transmitted 10 times at a rate of 9600 baud at 2.5 watts, but received only partial messages.

From Site Two, transmissions were sent at 30-second intervals, and both radios transmitted at 4.1 watts. We received 42 out of 70 standard ALERT transmissions for a success rate of 60%. From the Integra, we received 35 out of 60 transmissions for a success rate of 58.3%.

Conclusions

We found that there was no significant difference between the success rate of 300 baud ALERT and 4800 baud Integra transmissions. The data content of the Integra

messages was nearly 9 times greater (35 vs 4 bytes), and was accomplished in 30% to 40% of the time of the ALERT messages. Since only error-free complete messages were counted in both cases, the bit error rate of the Integra transmissions is apparently significantly lower (better) under comparable conditions.

We intended that these tests would be a simple pass-fail elimination trial. The goal was to determine if there was any technological basis for trying to apply modern modulation schemes within the existing ALERT environment. A success in transmitting from just two difficult sites in only one weather/climate condition does not prove beyond doubt that the new methods will work universally. However, we believed a failure to perform comparably to existing ALERT sites under marginal conditions would be good cause to drop the efforts before more resources were invested.

These results show that the technological possibility of a 4800 baud ALERT protocol cannot be dismissed. We believe they make a convincing argument that further development and testing of an improved ALERT transmission scheme is justified. Such a scheme could increase the data content of ALERT messages by an order of magnitude, and at the same time, increase channel capacity 2- to 3-fold.

The next steps will involve building several prototype units that could be integrated with existing ALERT hardware and field-tested under a variety of conditions. This will require the development of ancillary equipment and software for receiving and decoding the prototype messages. It will also require stipulation of a data protocol to be used during the prototype stage. In order to proceed, there needs to be agreement concerning how the work is to be funded, who will coordinate it, and how access will be provided to the results. Front-end effort must also go in to a transition plan that ensures that new equipment will be inter-operable with existing ALERT hardware in mixed systems.

We believe that all members of the ALERT community are players in this process. Participation of the hardware and software vendors is critical, but competitive pressures make it difficult for them to fund this process and keep it open and non-proprietary at the same time. The ALERT user community needs to demonstrate a commitment to the use of this technology if it is developed, and help define the form and content of the new protocol around their needs. We believe the regional and national user's groups provide the ideal forum for the coordination of these efforts, and the appropriate source for seed funding to do the initial prototype development.