PROPOSAL TO INCREASE TRAFFIC CAPACITY IN THE UDFCD ALERT NETWORK

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OneRain Inc, Blue Water Design LLC, and Telos Services Inc.

The ALERT data contention study completed earlier this year concluded that there is an immediate need to create additional channel capacity in the Denver ALERT network. Increased network capacity will assure system integrity during peak-traffic events, as well as provide for anticipated growth. We propose to address the data contention problem by initiating a phased restructuring of the telemetry backbone.

Capacity can be increased through the addition of ALERT channels on new frequencies. A second, more forward-looking alternative is to begin the transition to ALERT-2 technology. Although ALERT-2 sensing devices will not be available in the near term, there is an opportunity to take advantage of the increased throughput and error detection and correction capabilities of the new protocol by deploying it on the repeater output channel.

Project overview

The ALERT contention study points out that improvements in system performance require channel enhancements on both the input and output sides of the repeaters. Our approach is to:

1. Create two ALERT input channels so the single channel load from any geographic area is halved. This requires reallocation of the existing input frequencies, the installation of new receiving equipment at the repeater sites, and the installation of modified repeater equipment.

2. Reduce contention on the output frequency by implementing ALERT-2 concentrating repeaters and ALERT-2 demodulators at base stations.

A phased implementation will permit the work to proceed at a rate consistent with available resources. It will permit a full season of side-by-side comparison of ALERT and ALERT-2 performance. It will provide meaningful improvements in system performance even as development of "production" ALERT-2 is completed.

We propose to begin in 2008 with the South repeater network (Smoky and Blue), as this is the most vulnerable to data losses from localized intense storms.

- About half the sensor transmitters that report through Smoky and Blue repeaters will be reprogrammed to the frequency now in use in Boulder County. Traffic from localized events will then be split across two input channels.

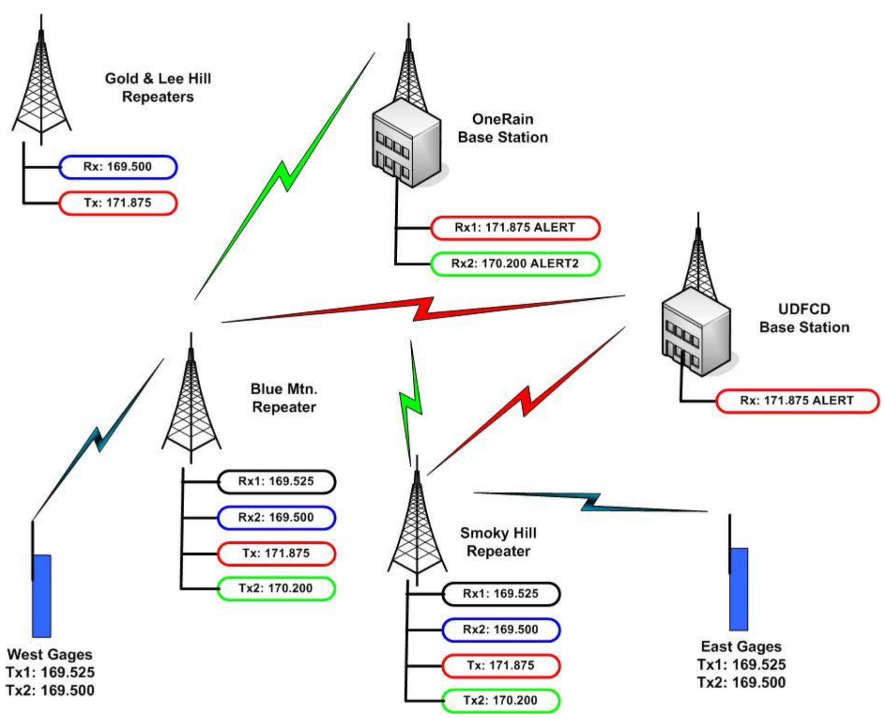
- Smoky and Blue repeaters will be modified to combine ALERT messages from the two input frequencies onto the existing UDFCD output frequency. At the same time, incoming ALERT reports will be fed to an ALERT-2 concentrating repeater.

- The ALERT-2 concentrator will combine messages from both input channels, buffer incoming messages briefly, then transmit as many messages as have arrived in 15 seconds in a single ALERT-2 transmission. These transmissions will be on a separate frequency.

- Production receiving equipment will be unchanged. ALERT-2 data will be captured at OneRain offices, where there will be an on-going program of evaluation.

- The ALERT-2 demodulator will process incoming packets to a serial data stream which will then be passed to a PC where forward error correction algorithms are applied and ALERT messages are reconstituted.

The architecture of the 2008 network is shown schematically below.



In 2009, the transition will be completed:

1. Smoky and Blue repeaters will be modified to remove ALERT output and move ALERT-2 to the operational output frequency.

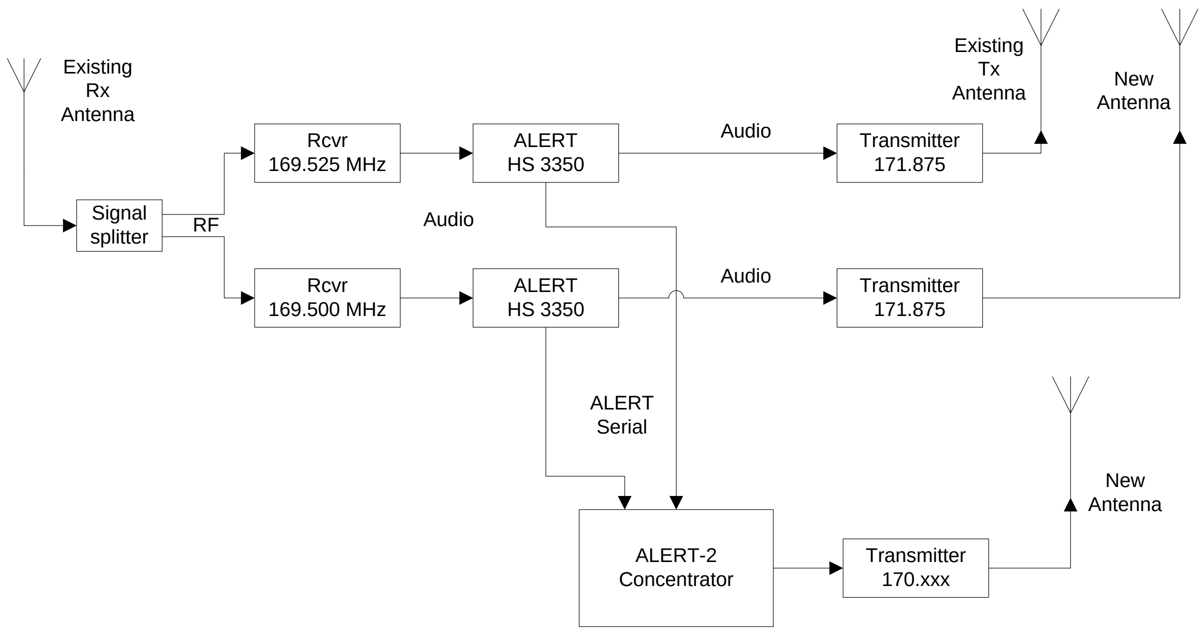
2. Base station receiving equipment will be upgraded from ALERT to ALERT-2 at all receiving sites.

3. Input channels will be split in Boulder County and ALERT-2 repeaters will be installed in Gold Hill and Lee Hill repeaters.

4. The receiving demodulator and FEC processing functions will be combined into a Linux–based single-board computer suited for production deployment.

Transition repeater architecture

The 2008 transition repeaters for Blue and Smoky have been designed to provide the functionality required to support two input frequencies, coordinated ALERT transmission on the output frequency, and simultaneous serial data input to the ALERT-2 concentrator. A schematic of one of the repeater sites is shown below.



Essential features of the transition repeater are:

- All electronic components shown on the diagram will be integrated into a single enclosure.

- By splitting the RF signal, the existing receiver antenna will serve two receivers. The audio signal from each receiver will be fed to its own High Sierra 3350 that will be programmed with an appropriate pass list. The 3350 will be remotely switchable among pass-list, pass-all and pass-none options, similar to the existing architecture. This functionality will be retained when the ALERT-2 system is fully operational.

- The audio output of each receiver will be directed to its own transceiver on 171.875 MHz. The HS 3350 will be capable of detecting that the output frequency is in use, and will buffer outgoing messages until there is “clear air.” This will reduce contention on the output channel of the production system and deliver a significant improvement in channel capacity.

- The serial outputs of the two HS 3350s will be fed to the BWD ALERT-2 concentrator. This will combine the data received on each input frequency and package one or more ALERT messages into ALERT-2 transmissions.

- The ALERT-2 transmitter will be on a separate output frequency that will be used during the transition period only.

The configuration changes required at the repeater sites are:

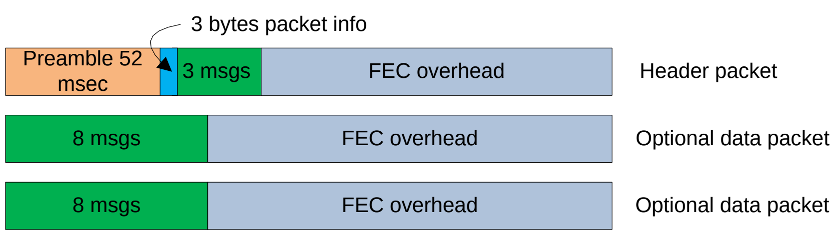
- The existing 50386 repeaters at Smoky and Blue will be removed and will serve as spares for the North system.

- Two new transmitting antennas will be installed at each site; these will be required only during the transition period.

- Power requirements will be reviewed, and additional solar/storage will be added if necessary.

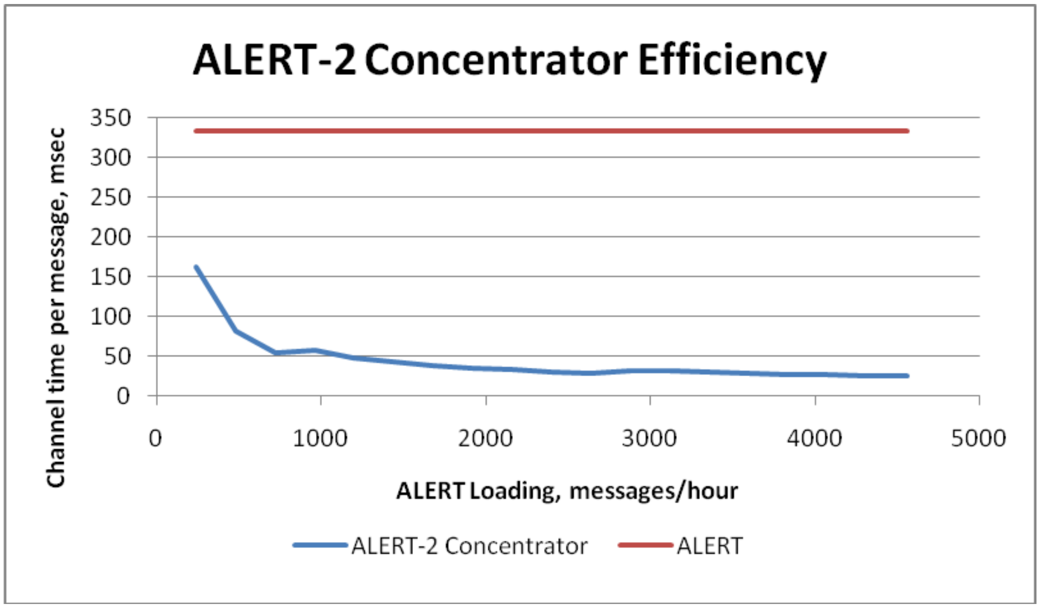
ALERT-2 concentrator
The ALERT-2 concentrator increases channel capacity in two ways. First, the initial ALERT-2 packet (header packet) has a total transmission time of 162 msec, compared to about 333 msec for an ALERT message. Even if only one ALERT message is sent in an ALERT-2 transmission, there is a channel capacity gain of 50%. Second, multiple ALERT messages can be sent in an ALERT-2 packet. The header can carry 3 ALERTs, and each subsequent data packet can carry 8 more.

ALERT Message



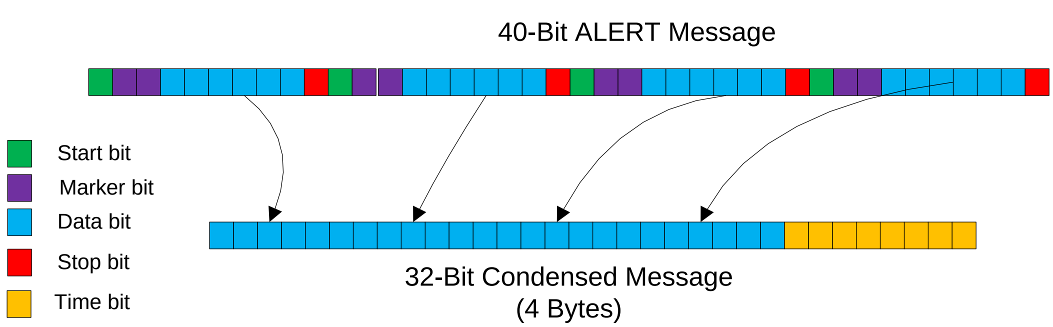
ALERT-2 Concentrator Message Structure

Since all ALERT messages arriving at the repeater in a buffering period will be sent in a single ALERT-2 transmission, channel efficiency increases as traffic increases. The graph below indicates that as ALERT input traffic approaches 5000 messages per hour, the ALERT-2 concentrator has a 13-fold improvement in throughput over ALERT.



The following describes the concentrator process in more detail:

- The ALERT-2 concentrating repeater monitors two ALERT input frequencies, buffering the input of each channel in the UART until it is called by the repeater program.
- At the arrival of the first message of a buffering cycle, a countdown timer is started. Each incoming message is processed to extract the 24 bits of data, and an offset timestamp of 8 bits is appended.



- Four-byte blocks of data are appended to the output message until the countdown timer expires (we are using a value of 15 seconds for this discussion; any duration is possible).

- At this time, the output message is processed into ALERT-2 packets with appropriate header information and error correction encoding. The ALERT-2 message is variable length, and will contain as many ALERT messages as arrive during the buffering period.

- At an input load of 2500 ALERT messages per hour, the ALERT-2 concentrator will transmit once every 15 seconds with a message duration less than that of a single ALERT message.

- At the receiving site, the ALERT-2 demodulator generates a serial stream which is then processed by the forward error correction module. The raw message will be time-stamped and logged during the test phase of this project.

- The raw message is then processed to reconstitute the message into 40-bit ALERT binary format. The time offset byte is read to determine the number of seconds that the message was buffered at the repeater.

- Existing ALERT data reception software cannot make use of the time correction byte. For this study, the ALERT data will be time-stamped by the base software without correction for latency.

ALERT-2 Development and implementation effort

The primary purpose of this project is to begin a course of improvements to the capacity of the UDFCD ALERT network. This is happening at a time when we are "on the cusp" of a transition to ALERT-2 technology; ALERT-2's benefits include not only greater channel efficiency, but error detection and correction, support for more sophisticated and accurate sensor systems, and two-way, network and control architectures.

Some increase in UDFCD channel capacity could be achieved by brute force addition of ALERT channels. Adding one more ALERT output channel would double system capacity, which would cut losses from the "model storm" from 77% to 53%. Another alternative would be to concentrate ALERT messages within the 300 baud ALERT format. This could double channel capacity by eliminating much of the ALERT preamble time. However, this approach would involve its own development and testing costs.

A single ALERT-2 concentrator, on the other hand, could forward "model storm" traffic with a channel loading of only 6%, and would provide performance equivalent to adding a dozen ALERT output channels. In addition, all errors introduced on the output channel would either be corrected or detected. There is no ALERT-based solution we are aware of that can approach the performance we expect from an ALERT-2 concentrator.

The transition path to ALERT-2 for all users will be to install an ALERT-2 backbone of repeaters and base receiving equipment that permits mixed installations of ALERT and ALERT-2 sensing sites. This project is directly on the ALERT-2 transition path. On the other hand, all resources applied to short-term fixes such as adding ALERT output channels will be sunk cost when the District later moves to ALERT-2.

Current development funding of ALERT-2 will end this month with the delivery of testing prototypes that have no operational application. An ALERT-2 concentrator is a modest development step that will provide the bridge between proof-of-concept and real-world application. Development effort that benefits the general ALERT community accounts for about one-third of the project cost.

Demonstration of ALERT-2 in a live environment is essential to continuing and expanding interest in the technology and ensuring its wider adoption. Doing the demonstration in the Denver area is ideal given the location of the primary developers of ALERT-2 technology.

Project Structure

OneRain will be the prime contractor, possibly as an extension of its existing consulting contract. The project team consists of OneRain, Blue Water Design, and Telos Services, with the principle contributors being Jake Emerson, Chris Roark, and Don Van Wie, respectively.

OneRain will perform all field work and integrate all components into a working network. Chris will perform the needed development and testing to deliver the ALERT-2 concentrator modulator and demodulator components that perform as described here. Don will serve as Project Manager; he will provide coordination among participants, maintain a focus on the testing and evaluation of system performance and provide reporting.

Construction planned on the East Cherry Creek Valley (ECCV) Water District building this spring has been a concern as it demands relocation of the Smoky Hill repeater. OneRain has been in contact with ECCV and their project manager to ensure that the repeater move is complete by March 2008. ECCV has reserved space for the repeater on their new towers which are scheduled for completion in February. This proposal includes the price of a new enclosure that we would mount on this tower to contain the repeater's electronic components. We will have a coordination meeting at ECCV in the next couple of weeks to solidify the details.

The project schedule is aggressive but can be achieved if funding is available promptly. The repeater external hardware changes will be completed ahead of spring start-up. Fabrication, programming and testing of the ALERT repeaters will begin on notice to proceed and be ready for startup. Distribution of transmitters onto a second input frequency will take place during the start-up cycle, and the dual-frequency system will be operational at that time.

It is our goal to have the ALERT-2 concentrator in place when the system becomes fully operational in spring. However, the hardware is configured so that the production system is not dependent on the presence of the ALERT-2 components.

Data will be collected from the ALERT and ALERT-2 systems, and analyzed on an on-going basis to determine data losses, errors, system integrity and performance. These results will drive ongoing development or modifications. At the end of the season, we will produce a summary report which will help direct the next steps.

Cost – restated 3/5/2008

OneRain proposes to deliver all hardware and services and functionality identified above for a total of $74,887. The costs have been broken down as follows:

Linux-based ALERT output ALERT-2 Decoder/Logger (1)	$ 18,365	
Development		$ 14,365
Implementation		$ 4,000
ALERT dual serial ingest concentrators (3)	$ 21,424	
Development		$ 4,924
Implementation		$ 16,500
Testing design, analysis and reporting	$ 11,840	
Development		$ 3,000
Implementation		$ 8,840
Frequency changes and base modifications	$ 2,160	
Repeater site modifications	$ 16,898	
Project management	$ 4,200	
Total	**$ 74,887**	

There are many facets to this project, and we look forward to discussing them with you at your earliest opportunity.