

# ALERT-2 Protocol Development

Final Report  
January 15, 2008

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Contract Number: DG133R-07-CN-0175

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This material is based on work supported by the Department of Commerce under contract number: DG133R-07-CN-0175. Any opinions, findings, conclusions or recommendations expressed in this publication are those of the author and do not necessarily reflect the views of the Department of Commerce.

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## 1. Project Summary

The ALERT-2 Protocol Development project documented the unmet market demand for, and demonstrated the technical feasibility of, a next-generation suite of wireless communications protocols for automated flood warning systems (AFWS). This project was funded by the Department of Commerce, National Oceanic and Atmospheric Administration (NOAA) as a Small Business Innovation Research (SBIR) Phase I contract. The work was performed by Salo IT Solutions, Inc. (SaloITS).

**Research Objectives** Many automated flood warning systems use the ALERT protocol, a simple wireless communications protocol that was developed in the mid-1970s. However, the original ALERT protocol is no longer able to meet the needs of large ALERT systems. The objective of this project was to document the market requirements for and demonstrate the technical feasibility of developing a successor to the original ALERT protocol, namely the ALERT-2 protocols. Specific research objectives included: (1) engage the AFWS community in discussions about its needs for a new wireless communications solution, and (2) demonstrate the technical feasibility of the ALERT-2 protocols.

**Research Activities** The following activities successfully achieved these research objectives:

- Created an ALERT-2 project Web site (<http://www.alert-2.com/>) which hosts e-mail discussion lists and makes the project documents readily available to any interested party;
- Wrote and made freely available an “ALERT-2 Requirements Specification” document; and
- Wrote and made freely available a preliminary “ALERT-2 Protocol Specification” document.

The Principal Investigator met on two occasions with members of the ALERT community, including users, vendors, hydrologists, and government officials, to review the documents created by this project and to discuss the needs and requirements for the ALERT-2 protocols.

**Findings and Results** Based on this work, SaloITS concludes:

- There is a clear, unmet need for a next-generation wireless communications solution that will replace the original ALERT protocol. The effectiveness of some ALERT systems is being adversely affected by the limitations of the original ALERT protocol.
- The AFWS market is small, and the ALERT vendors are unlikely to develop a solution without outside investment.
- The preliminary ALERT-2 protocols developed by this project, in conjunction with the modem funded by an earlier NOAA SBIR project, will address these unmet needs and provide enhanced reliability and functionality to AFWS systems.

**Commercial Applications** The immediate application of the technologies developed by this SBIR Phase I project, and the solutions that would be developed by a follow-on SBIR Phase II project, is to alleviate the congestion, packet loss, and poor performance experienced by many large ALERT systems. These technologies will also facilitate the development of new products and features that will reduce the cost of operating ALERT networks and provide new sales opportunities for vendors.

## 2. Research Objectives

The principal objective of this project was to demonstrate the feasibility of, and provide a firm foundation for, a successful SBIR Phase II project that will implement the ALERT-2 protocols. The ALERT-2 protocols are a suite of next-generation wireless communication protocols that will provide enhanced services to Automated Flood Warning Systems (AFWS). The focus of this initial project was to create, and develop a consensus within the AFWS community in support of, an ALERT-2 Requirements Specification document and a preliminary ALERT-2 Protocol Specification document.

All of the research objectives described in this section were successfully achieved.

The ALERT-2 Requirements Specification was intended to record the unmet needs that a next-generation suite of protocols for automated flood warning systems should address. Its audience was to include users of flood warning information, flood warning system operators, government agencies responsible for flood warnings and flood warning systems, and vendors. This document was intended to provide a benchmark against which the ALERT-2 Protocol Specification could be evaluated. The document was to be widely disseminated throughout the AFWS community for review discussion and comment; it was to be revised in response to these review comments.

The ALERT-2 Protocol Specification was to describe the technical details of the proposed protocols. The ALERT-2 protocols were to be flexible and extensible. They were to support a broad range of sensor, reporting station, and network configurations, and were to be designed so that new functionality could be added gracefully, without adversely affecting existing products or deployed networks. This document was to be written by SaloITS, circulated to all interested parties for review and comment, and subsequently revised.

This open design process was intended to leverage both the technical expertise of SaloITS and the operational experience and domain knowledge of the AFWS community. The objective of this collaboration was to ensure that the ALERT-2 protocols employ the best available technology and meet the current and future needs of the AFWS community.

The ALERT-2 protocols were intended to be open and non-proprietary. The freely available protocol specification was to be written with the clarity and level of detail necessary to ensure interoperability between products and vendors: products that conform to the specification were to be assured of interoperating with other conforming products. The open, non-proprietary nature of the protocol specification was to ensure that the benefits of the technologies developed by this project would be available to all automated flood warning system vendors. Furthermore, the assurance of interoperability between products and vendors would simplify the task of acquiring, deploying, upgrading, operating, and maintaining ALERT-2 products and networks.

## **2.1 Work Task Plan**

This Phase I project was to include the following tasks (all of which were successfully completed):

1. Establish collaborative tools and processes
2. Write ALERT-2 Requirements Specification document
3. Create ALERT-2 Protocol Specification document
4. Undertake necessary modeling or proof-of-concept implementation
5. Develop ALERT-2 Implementation Plan document
6. Write interim and final reports

## **2.2 Deliverables**

Deliverables for this project were to include the following (all of which were successfully delivered):

- ALERT-2 Project Web pages, including an e-mail archive and a document repository
- ALERT-2 Requirements Specification document
- ALERT-2 Protocol Specification document
- ALERT-2 Implementation Plan document
- Phase I final report and other reports as required by the contract

### **3. Research Activities**

This Phase I project included the following research activities and several other notable events.

#### **3.1 Collaborative Tools and Processes**

The ALERT-2 Protocol Development project Web site (<http://www.alert-2.com/>) was created to facilitate communications with the ALERT community about this project. It provides access to the documents created by this project and supports discussions related to the project. The ALERT-2 project home page has been accessed over 375 times, although this count includes multiple accesses from a single host or site and accesses by search engines.

#### **3.2 ALERT-2 Requirements Specification Document**

The ALERT-2 Requirements Specification document identifies the unmet needs that the ALERT-2 protocols must address. It concludes that an optional two-way protocol is required in order to meet some of the needs identified by ALERT users, such as the ability to manage ALERT nodes remotely over the network. To meet these needs, the document specifies that the ALERT-2 protocol should provide three types of service:

- A best-effort datagram service, where an application transmits a single packet and hopes that it is received correctly. This is equivalent to the service provided by the original ALERT protocol.
- A reliable datagram service, where an application transmits a single packet and the network takes special measures to ensure that the packet is successfully received by the intended recipient.
- A reliable packet stream service, where an application transmits a block of data (anything from a short message to a file) and the network ensures that all of the data are received, without error and in the correct order.

The Requirements document emphasizes the need to continue to support one-way, transmit-only nodes and networks.

The contents of the Requirements document appear to reflect a strong consensus of the ALERT community. Nonetheless, a small minority of the ALERT community (perhaps fewer than half-a-dozen people) apparently believes that only modest changes should be made to the original ALERT protocol, even though this approach does not meet the needs identified in the Requirements document.

The first draft of the Requirements document was published on August 27, 2007 and was announced on the Yahoo Floodsystems e-mail list a few days later. This initial draft was downloaded dozens of times, perhaps a few hundred times, although the exact count is unavailable. Only one set of unsolicited comments on this document was received. The

Principal Investigator also solicited comments by phone from a number of members of the ALERT community. Many of these conversations were very informative.

A second draft of the ALERT-2 Requirements Specification document was written in late December. This draft, which was not originally planned, was prompted by the October 24, 2007 meeting with several senior members of the ALERT community (described below) and a series of e-mail exchanges. Although the user requirements themselves changed little, considerable new background material was added in this version and the more technical contents were moved to the ALERT-2 Protocol Specification document.

The third and final version of the Requirements document notes that the ALERT community has a very strong desire for an open-source implementation of the ALERT-2 protocols.

All of these documents are available on the ALERT-2 project Web site at <http://www.alert-2.com/documents.html>. The final version of the ALERT-2 Requirements Specification document is included as Attachment A of this document.

### **3.3 Preliminary ALERT-2 Protocol Specification Document**

A preliminary ALERT-2 Protocol Specification document was written and made freely available on the ALERT-2 project Web site. This document describes a suite of layered wireless communications protocols that will provide a more functional alternative to the original ALERT protocol. These protocols offer the three classes of service that were described previously:

- Best-effort datagram service – transports through the network a single packet containing information provided by an application; the ALERT-2 protocols make no effort to recover packets that are lost due to transmission errors, collisions, or congestion. (This is equivalent to the service provided by the original ALERT protocol.)
- Reliable datagram service – transports a single packet containing application data; the ALERT-2 protocols attempt to recover packets that are initially lost due to transmission errors, collisions, or congestion.
- Reliable packet stream service – reliably delivers a sequence of packets containing application data (such as a log file or configuration file).

This initial ALERT-2 Protocol Specification is a preliminary document; its contents may be refined as a result of field trials and early operational experience.

This document is available on the ALERT-2 project Web site at <http://www.alert-2.com/documents.html>. The final version of the ALERT-2 Protocol Specification document is included as Attachment B of this document.

### **3.4 Preliminary ALERT-2 Implementation Plan Document**

A preliminary ALERT-2 Implementation Plan document was created and is included as Attachment C of this document. This is a preliminary version of a plan that will be included in the Phase II proposal to implement the ALERT-2 protocols.

### **3.5 Other Significant Activities**

Two very productive meetings warrant special mention.

#### **3.5.1 October 24, 2007 ALERT-2 Working Meeting**

Mr. Salo, the Principal Investigator for this project, met in Sacramento on October 24, 2007 with five other members of the ALERT community. The very productive, four-hour meeting focused on the ALERT-2 Protocol Development project. The following people participated in the meeting:

- Joe Johnson, HydroLynx Systems, Inc.
- Dave Leader, Vice President, HydroLynx Systems, Inc.
- Todd Mendell, Senior Hydrologist, National Weather Service
- Rob Nelson, Past President, Alert Users Group
- Tim Salo, Salo IT Solutions, Inc.
- Jim Slouber, Vice President, High Sierra Electronics, Inc.

The focus of the meeting was the requirements for the next generation of the ALERT protocol. The Principal Investigator led the group through a page-by-page review of the ALERT-2 Requirements Specification document.

The group concluded that:

1. The ALERT-2 protocols must support one-way networks, networks in which some or all of the remote nodes transmit but do not receive. These one-way networks will benefit from the new modem being developed by Blue Water Design, but will otherwise receive limited benefits from the new ALERT-2 protocols.
2. The ALERT-2 protocols should include optional two-way protocols that leverage the ability of nodes to receive as well as to transmit. In these environments, the new ALERT-2 protocols will offer the services described in the ALERT-2 Requirements Specification.



### **3.5.2 January 10, 2008 ALERT-2 Working Meeting**

An expanded group met in Longmont, Colorado on January 10, 2008. The objective of this meeting was to understand how we can collectively move towards delivering solutions to ALERT users. This meeting was a significant step towards achieving that objective.

The following people attended the meeting in Longmont:

- Jake Emerson, OneRain
- Ilse Gayl, CEO, OneRain
- David Haynes, President, Distinctive AFWS Designs, Inc.
- Glenn Hechler, OneRain
- James Logan, President, OneRain
- Jim Longthorne, Los Angeles County, retired
- Chris Roark, Blue Water Design, LLC
- Tim Salo, Salo IT Solutions, Inc.
- Jim Slouber, High Sierra Electronics  
Kathy Slouber, High Sierra Electronics
- Kevin Stewart, Urban Drainage and Flood Control District, Denver, Co; President, National Hydrologic Warning Council
- Don Van Wie, Telos Services

Several people also participated via phone:

- John Bradley, National Weather Service
- Steve Waters, Flood Control District of Maricopa County, AZ
- Todd Mendell, NWS California-Nevada River Forecast Center

During the meeting, the results of the ALERT-2 Protocol Development project were reviewed, as were those of the Blue Water Design ALERT modem development project. Following that, the group discussed how the community should move towards delivering an enhanced solution to customers. The group will meet again in late February 2008.

## 4. Findings and Results

The most significant conclusions of this project are:

1. The ALERT community has a serious and long-standing need for a more capable alternative to the original ALERT protocol. Large ALERT networks are experiencing significant performance problems during normal operations and even more serious problems during major rain events. These problems are a direct result of the design of the original ALERT protocol.
2. The ALERT community is unlikely to develop a successor to the original ALERT protocol without outside investment. The market is small and apparently cannot support the level of investment required to develop a new solution. It also appears likely that technical expertise beyond that which is readily available within the ALERT community would enhance the chances of successfully developing a successor to the original ALERT protocol.
3. The ALERT-2 protocols outlined by this project are technically feasible and will address the unmet needs of the ALERT community. Furthermore, the ALERT-2 protocols will help reduce the cost of maintaining an ALERT network and will provide opportunities for ALERT vendors to develop and market new products, services and functionality.

Additional observations include:

- The ALERT-2 protocols must provide a graceful migration path for networks that are currently using the original ALERT protocol. Furthermore, the ALERT-2 protocols should support transmit-only nodes and networks, although they will be able to provide only limited functionality in these environments.
- The modem developed by Blue Water Design LLC is an important component of an enhanced solution for ALERT systems.
- The ALERT community has a very strong desire that the ALERT-2 product developed by a follow-on Phase II project be open-source.
- A follow-on Phase II project must provide a complete solution, an integrated device that provides all of the necessary functionality beyond that provided by a modem and a data logging device.
- Many of the performance problems experienced with the original ALERT protocol are directly caused by the lack of a media-access layer (MAC) protocol. (A MAC protocol enhances the performance of a wireless communication protocol by controlling collisions between packets. It does this by determining when a particular station may transmit on a radio channel.) A successful Phase II project must design and implement a MAC protocol that is appropriate for ALERT systems.

## **5. Technical Feasibility**

This project, in the opinion of SaloITS and as stated above, successfully and unequivocally demonstrated that:

- The ALERT community needs a new suite of wireless communications protocols that provides better performance, greater functionality, and more extensibility than does the original ALERT protocol;
- The preliminary ALERT-2 protocols developed by this project are technically feasible; and
- These ALERT-2 protocols will meet the ALERT community's needs.