Tracking and Monitoring Nuclear Material and Waste Packages by Using the ARG-US Radio Frequency Identification System* - 11230

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ABSTRACT

ARG-US has been developed for real-time tracking and monitoring of nuclear material and waste packages during transport and storage. The system allows for continuous monitoring from cradle to grave, including waste disposal. The system consists of active Radio Frequency Identification (RFID) tags attached to the packages; each tag has a suite of sensors that collect data on temperature, humidity, seal status, physical shock, and battery status. Data from the tag sensors during normal operation, or alerts/alarms during abnormal conditions, are first collected by an RF reader (or interrogator) and then transmitted via satellite, cellular, or secured Internet to a central database server at a pilot Command Center at Argonne National Laboratory. Upon receiving the data, the operators at the Command Center can determine the status (i.e., the state of health) of the packages and take appropriate actions for emergency response, if deemed necessary, or clear the alarm via a secured website.

INTRODUCTION

A system, called ARG-US, has been developed for the real-time tracking and monitoring of nuclear material and waste packages during transport and storage. The system allows for continuous monitoring from cradle to grave, including waste disposal. The system consists of active Radio Frequency Identification (RFID) tags attached to the packages; each tag has a suite of sensors that collect data on temperature, humidity, seal status, physical shock, and battery status. Data from the tag sensors during normal operation, or alerts/alarms during abnormal conditions, are first collected by an RF reader (or interrogator) and then transmitted via satellite, cellular, or secured Internet to a central database server at a pilot Command Center at Argonne National Laboratory. Upon receiving the data, the operators at the Command Center can determine the status (i.e., the state of health) of the packages and take appropriate actions for emergency response, if deemed necessary, or clear the alarm via a secured website. The performance of the ARG-US system has been demonstrated previously [1]; this paper will present results in recent field testing and applications of ARG-US at selected DOE sites.

TAG HARDWARE

The ARG-US RFID tag is a 433-MHz, active RF device containing a suite of sensors that are powered by long-life (>10 yr) batteries, with an omnidirectional read range of ≈ 100 m. One set of sensors monitors the environment of the package, including temperature and humidity. Another set of sensors, including

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a seal integrity sensor and a physical shock detector, monitors the physical state of the package. If any of the sensors report a value beyond the preset thresholds, a tag-initiated message will be sent to an RFID reader, triggering an alert/alarm. In parallel with the environmental monitoring, the tags are polled by the reader at a preset interval. If a tag does not respond to the poll, a "No Response" alarm is generated, alerting the system that there may be a problem with the package (e.g., absence or a drained tag battery) that needs to be investigated. Depending on the scenario, the polling interval can be adjusted from every few seconds during transport to multiple hours during storage. The ARG-US RFID tag also contains non-volatile memory that can be used to store historical sensor data, encrypted user comments, and an encrypted manifest of the contents of the package. The tag has a built-in clock that can be used as part of the automatic tickler system for handling and processing materials and waste packages, supplementing administrative controls.

The current tag implementation uses standard commercial electronic components. In laboratory gamma irradiation tests with a calibrated Cs-137 source, tag electronics withstood radiation doses of up to 31 krad before the RF performance started to degrade. This dose level corresponds to ≈17 years of service in a field of 200 mR/h, which is the regulatory dose rate limit on the surface of Type B packages. For highly radioactive nuclear wastes packages, more radiation-resistant tags may be needed. Development of a next-generation tag that will integrate a radiation dosimeter into the sensor suite is under way. Just like the existing sensors, the radiation dosimeter will allow the tag to issue an alert/alarm for threshold violation and for replacement when the accumulated dose reaches the end-of-life allowance.

SYSTEM OVERVIEW

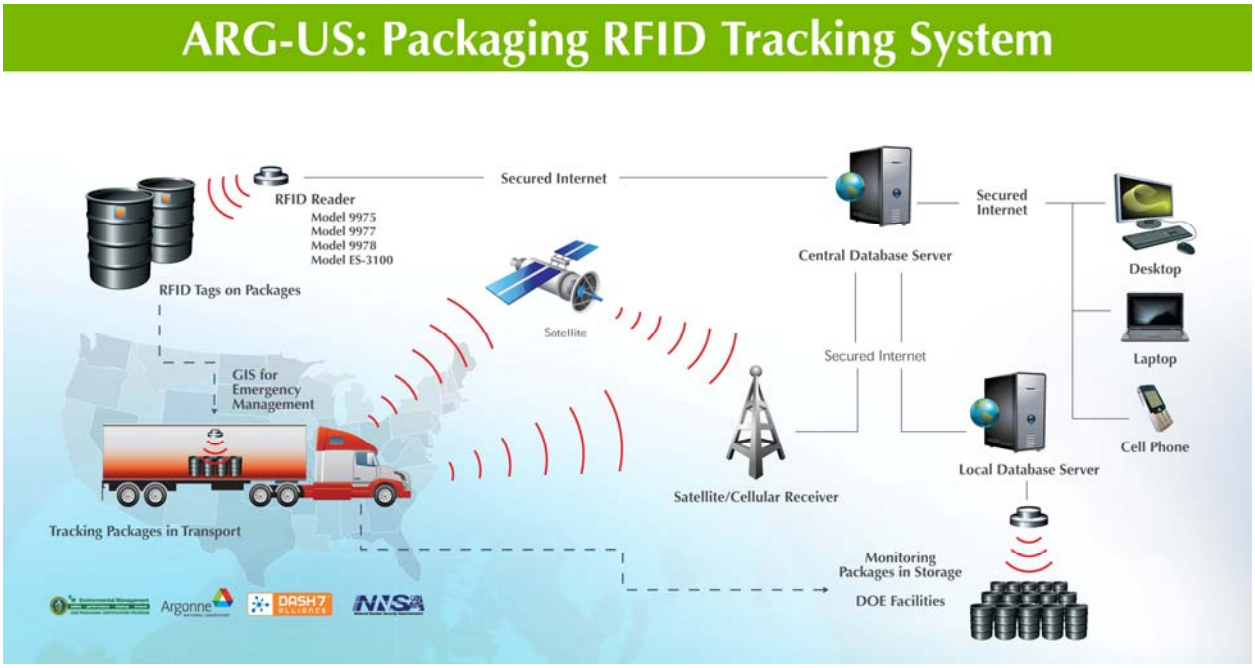

Figure 1. Overall view of the ARG-US System

For the system to be able to track a package from cradle to grave, multiple ARG-US RFID readers must be installed at various storage and disposal locations, as well as on the transport vehicles, as illustrated in Figure 1. A control computer will query the RFID tags and transmit the data and the storage/disposal

location ID to the central database server at the Argonne pilot RFID Command Center. The data are transmitted over the Internet via Hypertext Transfer Protocol Secure (HTTPS) using a Secure Socket Layer (SSL). During transport, a reader is mounted in a truck trailer and connected to the control computer in the cab. The control computer reads the Global Positioning System (GPS) information and the RFID tag sensor data and transmits the coded message back to a secure central server through either satellite or cellular communication. The server automatically interprets the coded message and archives it in the secure central database. After the packages reach their destination, monitoring is switched over to the destination's control computer, along with its own ARG-US system. The switch can be performed manually by using the ARG-US OnSite software on the control computer. The protocol for automatically transitioning between sites and transport vehicles using a combination of RFID readers and signposts/ portals is under development.

USER INTERFACE

Figure 2 is a screen capture of the ARG-US OnSite application, whereas Figure 3 shows the ARG-US web interface captured during a recent post-integration road test of the ARG-US system and the DOE TRANSCOM.

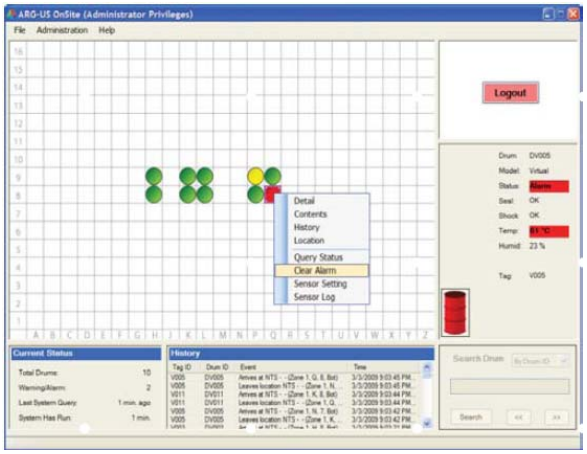

Figure 2. Screen capture of the ARG-US OnSite application

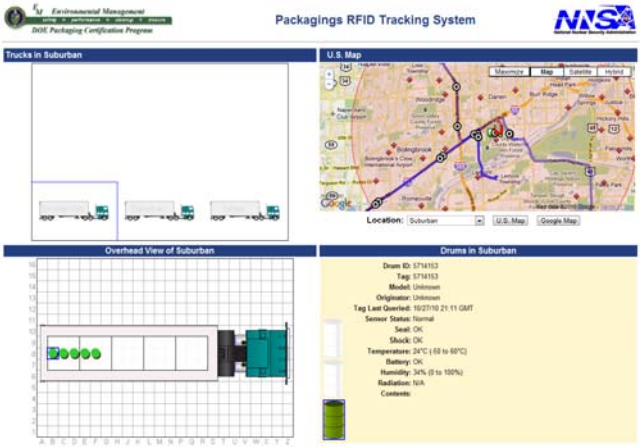

Figure 3. Screen capture of the ARG-US Web interface

SUMMARY

The ARG-US system has been developed for the real-time tracking and monitoring of nuclear material and waste packages during transport and storage. The system allows for continuous monitoring from cradle to grave, including waste disposal. Several ARG-US systems are undergoing field testing and applications at selected DOE sites.

ACKNOWLEDGMENTS

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REFERENCE

1. H. Tsai, et al., "Demonstration (DEMO) of radiofrequency identification (RFID) system for tracking and monitoring of nuclear materials," Packaging, Transport, Storage & Security of Radioactive Material, 2010, Vol. 21, No. 2.