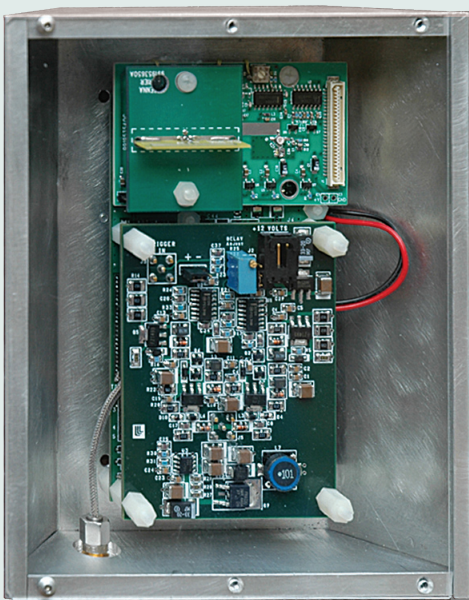


Protecting the Nation through Secure Cargo

EVERY year, more than 200 million cargo-container shipments transport 90 percent of the world's cargo. Over 11 million of these shipments arrive in the U.S., carried on ships, trains, planes, and trucks. National security officials view cargo containers as a potential means for terrorists to import a weapon of mass destruction into the U.S.

Several security mechanisms, such as special door locks and electronic seals, have been implemented to protect the integrity of containers during transit. None, however, is as cost-efficient or reliable as SecureBox, a new device developed by Lawrence Livermore in collaboration with



SecureBox is a wireless device that can be installed within the metal corrugation of a cargo container to detect intrusions.

Secure Box Corporation of Santa Clara, California, and the National Infrastructure Institute.

The development team, led by systems engineer Kique Romero, received initial funding from Livermore's Laboratory Directed Research and Development Program and, in 2008, won an R&D 100 Award for the technology. SecureBox uses Livermore-developed ultrawideband (UWB) radar and communication technology to accurately detect intrusions along any of a container's six walls. The compact device, about the size of a 12-ounce soda can, fits within the metal corrugation of common cargo containers. If an intrusion is detected, SecureBox transmits alarm reports to authorized individuals. In transatlantic field tests using containers shipped by different transportation modes, SecureBox achieved a 100-percent probability of intrusion detection and a zero false-alarm rate.

Electromagnetic Security Bubble

UWB technologies use extremely short electromagnetic pulses (from 50 to 100 picoseconds, where 1 picosecond is 10^{-12} seconds) to transmit and acquire data across a broad range of radio frequencies. UWB systems offer considerable advantages for tracking and monitoring cargo containers when compared with conventional narrowband technologies, which transmit higher average-power, continuous-wave signals over specific frequencies. The short pulses and broad spectrum of UWB systems make the signals difficult to detect and allow them to function in harsh radio environments, such as the hold of a ship.

In addition, low power requirements permit operation for a much longer time than narrowband technologies using a battery with equivalent capacity.

SecureBox incorporates the Livermore-developed technology used in GUARDIAN, the general-purpose undetectable autonomous radar detection imaging and notification system. This UWB motion detection system transmits millions of subnanosecond radar pulses and detects changes in echo signals reflected back to the sensor. The GUARDIAN sensor uses precision timing techniques to selectively evaluate echo signals arriving at the sensor from a specific distance.

GUARDIAN turns this invisible ping-pong of electromagnetic pulses into a protective semispherical bubble around the container walls. A bubble-shaped electromagnetic field might seem to be ineffective at protecting a rectangular container. However, an innovative folded-bubble method developed by the Livermore team takes advantage of reflections from the container's metal walls to precisely time the received echo signals while maintaining sufficient signal energy to trigger the alarm.

Once a container is sealed for transport, any breach of its walls disrupts the radar's echo pattern and activates an alarm. SecureBox systems also include sensors, such as accelerometers, to help differentiate movement by an intruder from the normal vibrations that occur during shipping.

Sending an Alarm

If an intrusion is detected, SecureBox transmits encrypted data through various communication modes to alert authorized individuals of the breach. The device's

communication system can transmit data up to 122 meters and works effectively even when a container is buried in a stack of other containers or located deep within the hold of a ship.

Commercial UWB communications systems designed for high data rates typically correlate the data pulse with a preset template. This technique does not work well inside ships because they are primarily made of metal. Metal surfaces create a massive number of reflections that distort or stretch the radio-frequency signals emitted by the sensor. Distorted signals are difficult to detect because they do not resemble the template of the transmitted energy.

To counter this issue, the Livermore team used the Laboratory's transmitted reference modulation technique in designing the communications radio for SecureBox. The radio transmits a pair of pulses, a modulated data pulse closely followed by an unmodulated reference pulse. Each pair has a designated binary value based on the relative polarity of the two pulses. During transmission, both pulses are stretched and distorted identically by the same environment. A reference receiver then correlates the pulses to detect the transmitted data stream. This technique enables the UWB communication system to function in highly metallic environments where traditional communication systems often fail.

A More Secure Future

Finding a reliable, cost-effective way to secure cargo containers has been a challenge for national security officials.



The SecureBox development team (from left): John Chang, Howard Lowdermilk, Bruce Henderer, Gregory Dallum, Richard R. Leach, Jr., Faranak Nekoogar, Garth Pratt, Vickie Abreu, Patrick Welsh, Kique Romero, Mark Vigars, James Zumstein, Peter Haugen, William Dunlop, Philip Top, and Christine Paulson. Not pictured: Stephen Azevedo, David Benzel, Kristian Chubb, Arden Dougan, Farid Dowla, Michael Newman, Ronald Shaw, and Kenneth Waltjen.

SecureBox remains the only tamper-proof device that can protect all six walls of a cargo container, whether the container is stationary or in transit. The device is also economical. Its UWB sensor components are made from commercially available products and are powered by small lithium batteries that can work for years without being recharged. The low power requirements also make SecureBox an appealing application for the transportation industry because the device's sensors do not interfere with normal radio operations.

SecureBox devices are available from Secure Box Corporation, which licensed the Livermore technology in 2007. Thanks

to the efforts of the development team, the nation has a more effective way of securing cargo and improving national security.

—Caryn Meissner

Key Words: cargo container, GUARDIAN, R&D 100 Award, SecureBox, security, sensor, transmitted reference modulation, transportation, ultrawideband (UWB) communications.

For further information contact Kique Romero (925) 423-2830 (romero29@llnl.gov).