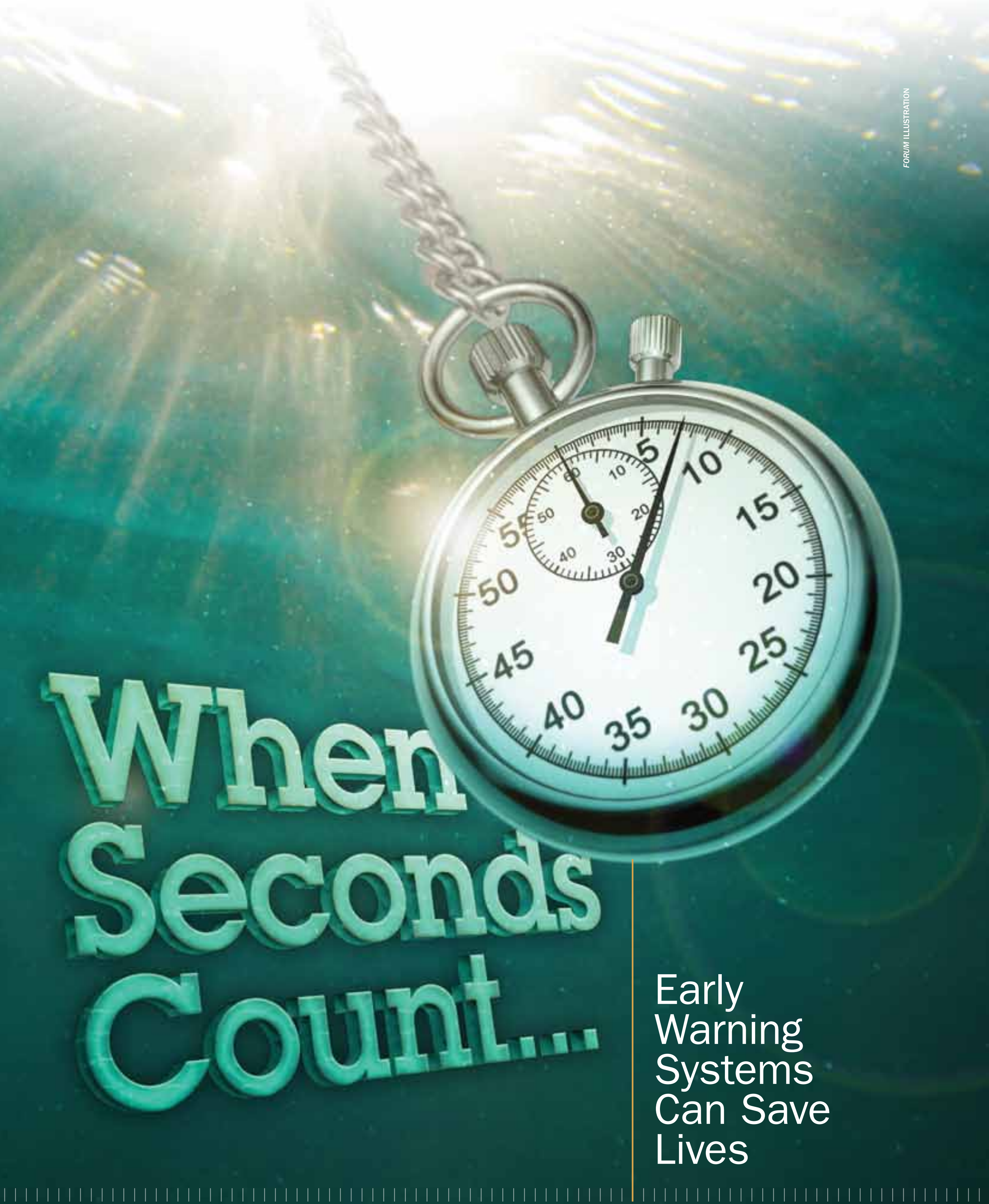

FORUM ILLUSTRATION

When Seconds Count...

Early Warning Systems Can Save Lives

AGENCE FRANCE-PRESSE

This stone erected in 1933 on a hillside in Aneyoshi in Japan's Iwate prefecture warns of the danger posed by tsunamis of past centuries. The inscription reads, "A house on high ground will lead to peace and happiness for posterity." That year a tsunami killed thousands along the rugged shore.

BY **JOHN BUMGARNER**

On the morning of December 26, 2004, a massive earthquake rumbled deep in the Indian Ocean. Within hours, tsunami waves slammed into the coastlines of 14 countries, killing more than 200,000 people and displacing almost 2 million more from their homes. Indonesia was the hardest hit, followed by Sri Lanka, India and Thailand.

Hailed as one of the deadliest natural disasters in recorded history, this catastrophic incident forged international determination to improve early warning systems for tsunamis. Despite limitations, as humans, in fighting nature, countries across the Asia Pacific have been working ever since to build tsunami-resilient communities. Deploying the latest technology to save lives has been a priority in many countries in the region. Critics, however, contend that progress has not occurred quickly enough, and more work needs to be done to better anticipate and guard against future events.

In March 2011, a major tsunami, also triggered by an undersea earthquake, struck Japan with waves tens of meters in height. Some waves traveled almost 10 kilometers inland. More than 15,000 people died, and the immediate secondary effects, such as power outages, affected millions more. Some of the secondary effects have been long-lasting and expensive. Damage to the Fukushima nuclear power plant on the Japanese coastline reduced the supply of electricity, threatened human health and required a costly cleanup that is ongoing. Overall, the cost estimates for this disaster hover in the tens of billions of dollars, making it the most expensive natural disaster on record.

In this disaster, however, early warning systems helped to avoid further loss of life in Japan, where the Japan Meteorological Agency (JMA) notified citizens about an earthquake capable of generating a tsunami off their coast seconds after the shaking began.

Countries to Japan's south, such as Indonesia and the Philippines, also activated their tsunami warning systems. They are connected to the Pacific Tsunami Warning System, run by the United Nations Educational, Scientific and Cultural Organization's (UNESCO's) Intergovernmental Oceanographic Commission. The system issued its tsunami warning within three minutes of the earthquake. In the Philippines, local governments evacuated more than 200,000 villagers in coastal regions. Although the waves that hit the coast proved to be only seven-tenths of a meter high, officials at the Philippine Institute of Volcanology and Seismology considered the evacuation a success, crediting automatic alerts sent by mobile phone for getting the warnings out effectively.

The risk of a natural disaster, and especially a tsunami, striking the Asia Pacific looms high compared to other regions of the world (see pages 26-27). While every day there is a 100 percent chance statistically that an earthquake will occur somewhere in the world, the most probable location for this quake, according to the U.S. National Oceanic and Atmospheric Administration, is along the Pacific Ocean's "Ring of Fire," which embraces the region. This, coupled with the fact that the Pacific Ocean is the most active tsunamic region, stacks the odds against the region.

In fact, several of the most destructive tsunamis, not only in the Pacific Ocean, but in the world, have hit

Japan. To mitigate the devastation associated with tsunamis, Japanese officials, aware of this history, have deployed an array of ocean monitoring cables and partnered with other nations to receive real-time tsunami warnings.

A Monitoring Network

The United States developed the foundation of the Pacific Ocean's tsunami warning system run by UNESCO. This highly critical system relies upon an array of sensors known as the Deep-Ocean Assessment and Reporting of Tsunamis (DART). The first sensors were deployed nearly a decade ago. The basic architecture of a single DART system consists of a buoy on the ocean surface and a tsunameter on the seafloor. Surface buoys are outfitted with a host of advanced electronics, including a global positioning system and bi-directional satellite communication equipment. Some buoys are also equipped with an array of other sensors, such as an anemometer to measure wind speed and a barometer to measure atmospheric pressure. Most tsunameters are also equipped with an acoustic transducer (wireless sonar) and a bottom pressure recorder.

When a tsunami traverses the ocean, the tsunameter on the seafloor measures pressure changes in the water above the sensor. These pressure readings are transmitted to the surface buoy through an acoustic modem. Once the surface buoy has collected the tsunameter reading, the reading is repackaged with additional sensor data (for example, sea temperature) and transmitted through the Iridium commercial satellite phone network, which immediately retransmits the information to multiple Tsunami Warning Centers, including the Pacific Tsunami Warning Center (PTWC) in Hawaii.

Within minutes of receiving the initial sensor data from a DART, the PTWC issues a bulletin to points of contact throughout the region. Organizations can issue additional internal country warnings depending on the severity of the initial bulletin. These country-level warnings can be disseminated to citizens living in areas that could be impacted by a potential tsunami.

Other ocean monitoring networks are coming online. In 2006, an Indian Ocean Tsunami Warning System was established that includes 25 seismic stations and 26 information centers. Nations along the Indian Ocean conducted the first full-scale test of the system in October 2011, including its communication and emergency response components. Bulletins were sent by telephone, email, SMS and fax to participants in more than 20 countries. India and Malaysia also conducted evacuation drills in concert with the test.

UNESCO has also been building an international network of tsunami sensors and country-level Tsunami Warning Focal Points to receive tsunami advisories around the clock. The Caribbean and Adjacent Regions and the North Eastern Atlantic, the Mediterranean and connected Seas Tsunami Warning System will be part of this global network. Researchers, UNESCO and other officials would like to see more tsunamographs — devices that deliver real-time data on tsunamis — deployed worldwide to make more accurate predictions about the duration of tsunamis possible. Inundation maps can supplement the arrays to show where flooding will most likely occur and how severe it might be in a given community.

UNESCO has pointed out that additional work needs to be done by national authorities to relay tsunami warnings more quickly to civilians at risk. The weakest link in all tsunami alert systems is timely localized warnings, experts explain. Regions closest to the epicenter of an earthquake that's capable of generating a tsunami face the shortest lead time. Communities in these areas can be impacted by tsunami waves within minutes after such an earthquake. The wave can hit land as a wall of water or sweep over land as a fast-moving flood. Tsunami floods can move faster than 24 kilometers an hour, making it difficult for people to evacuate to higher ground fast enough even if a warning is sounded.

Some of the catastrophic tsunami waves associated with the Sumatra-Andaman earthquake of 2004 came ashore within 20 minutes, within 15 minutes during the Tohoku earthquake of 2011 and within 10 minutes of the Sumatra earthquake of 2010. Tsunami floods can also last for

Indian scientists work at the state-of-the-art Tsunami Early Warning Centre of the Indian National Centre for Ocean Information Services in Hyderabad in February 2011.

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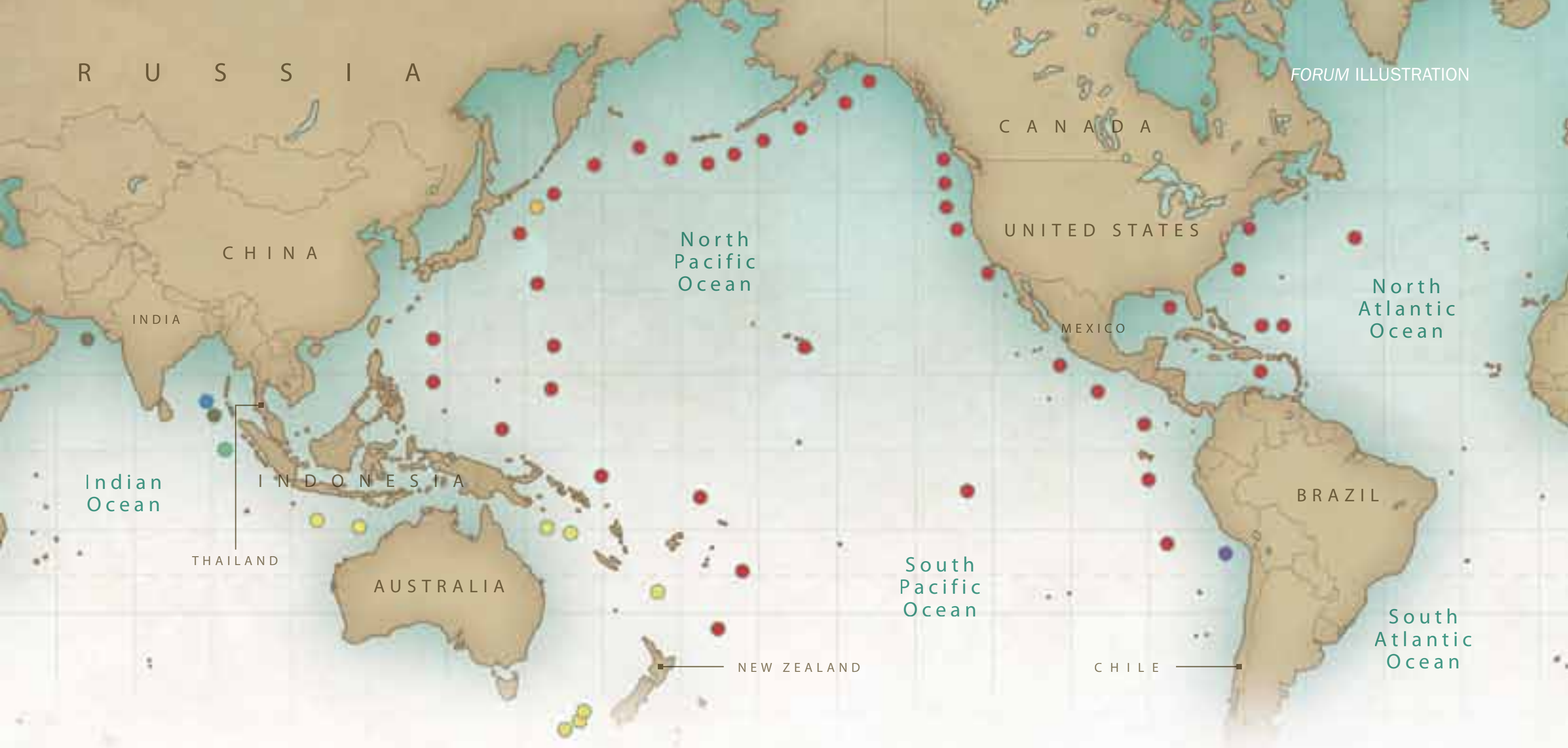

DART[1] System Stations

United States NDBC[2] · Australia · Chile · Indonesia · Thailand · Russia · India

[1] DEEP-OCEAN ASSESSMENT AND REPORTING OF TSUNAMIS
[2] NATIONAL DATA BUOY CENTER

hours, thwarting search-and-rescue efforts. Moreover, if warnings aren't properly extended, people who evacuate can return to their homes too soon, only to be hit by secondary flooding.

Japan currently has the most advanced Earthquake Early Warning (EEW) services in the world. When a regional seismometer detects an earthquake, it immediately signals the JMA, which can then issue an EEW alert through radio, television and cellular providers. The JMA can also trigger sirens in coastal areas that could be impacted by a tsunami associated with the earthquake. This high-tech warning system has provided millions of Japanese citizens with those invaluable seconds needed in a life or death disaster.

Expanding Warning Services

Many of the countries within the Asia-Pacific region desperately need to establish an end-to-end Earthquake and Tsunami Warning Service (ETWS). End-to-end refers to a system that incorporates individual components operating in sequence to produce a fully functioning system. The basic sensor architecture of these types of systems would include seismometers, tsunameters and tidal gauges. Readings collected by these sensors would be transmitted to regional warning centers via wired or wireless communication channels. The tidal gauges would also be directly linked with public announcement systems in the immediate coastal area.

Warning centers need to be able to rapidly disseminate the ETWS information across multiple media 24 hours a day in various weather conditions and to different audiences, such as foreign tourists and citizens with disabilities. Accomplishing this arduous task is challenging but not impossible. For instance, a public announcement system can be fitted with flashing lights, which can provide visual warning to those with hearing impairments, and play audible warnings in multiple languages to reach non-native speakers. Similar techniques can be used in television announcements.

Disseminating warnings to cellular phones via text-messaging services has proven useful in past natural disasters. Using this type of warning channel can be problematic, though, because the phone subscriber might not see the message in a timely manner. Installing specialized ETWS software on all cellular phones in the country could potentially alleviate this problem. This software could be designed to play an audible warning, flash the screen with a warning message and vibrate the phone. Service providers could trigger the software based on the location of the phone in relation to the ETWS warning.

As more technology advancements are achieved in ETWS systems, experts hope the world will see a dramatic reduction in the unnecessary losses of life in natural disasters. Unfortunately, earthquakes and tsunamis can never be prevented, but their impact can be mitigated through community preparedness, timely warnings and effective response. ☐

John Bumgarner is chief technology officer for the U.S. Cyber Consequences Unit. He has served as an expert source for various publications, including *Businessweek*, BBC, CNN, *Jane's Defence*, Reuters, *The Guardian* in London and *The Wall Street Journal*.