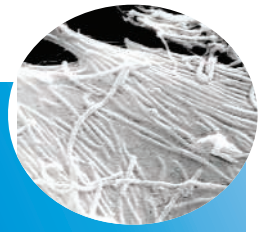

A Selection of Select Agents

Smallpox virus
Crimean-Congo hemorrhagic fever virus
Lassa fever viruses
Central European tick-borne encephalitis
Yersinia pestis (plague)
Foot-and-mouth disease virus
Ebola viruses ▶
Ricin
Tetrodotoxin
Bacillus anthracis (anthrax)
Venezuelan equine encephalitis virus
Botulinum neurotoxin

terms. But the change will reduce efficiency and timeliness, he says.

"Basically, the NIH [U.S. National Institutes of Health] left me with little choice," because it would have taken "months or years" to bring overseas labs into compliance, Weaver says. Already, the labs in Colombia and Venezuela store many VEE virus isolates in their freezers: Preventing the isolation of a few more strains, he says, will not deny the virus to a potential terrorist.

Although security at foreign facilities working with select agents generally has been strengthened since the 9-11 attacks, most labs would still run afoul of the new U.S. rules. Many outside the United States appear to be unaware of the regulations. "I haven't heard much," says Lev Sandakhchiev, director general of the State Research Center of Virology and Biotechnology, a former bioweapons lab near Novosibirsk, Russia, that collaborates with the United States on smallpox research.

Foreign researchers say they hope to find a way to continue working with U.S. counterparts because it would bolster security in their home countries. "If collaborations will continue, that will inevitably bring the standards up," says Bakyt Atshabar, director of the Kazakh Science Center for Quarantine and Zoonotic Diseases in Almaty, Kazakhstan, which specializes in studying endemic plague with Pentagon funding (*Science*, 17 December, p. 2021).

ASTMH and other societies intend to lobby for a relaxation of the rules. "The approach to this will not be easy," says Peter Weller, an immunologist at Harvard Medical School in Boston and ASTMH's most recent past president. For one, many agencies will want to weigh in on any change of policy. Second, Weller says, "the facile reply is that you scientists gave the Pakistanis nuclear secrets; how do we trust you on these issues?" In an e-mail response to questions from *Science*, NIAID officials say they expect no change to the select-agent terms "in the immediate future."

But some experts such as Keim say raising global security levels to U.S. standards makes sense. "We should not allow U.S. researchers to avoid regulatory oversight by going abroad. This would certainly apply to human subjects in clinical trials and animal-care standards in animal protocols. Why not security of dangerous pathogens?"

Critics of the policy say they are not opposed to strengthened security overseas. Rather, they decry how the U.S. government is going about it. NIH "seems to be hell-bent on enforcing the regulations," says Thomas Monath, chief scientific officer at Acambis in Cambridge, Massachusetts, and president of ASTMH. He wonders whether his company's research on Japanese encephalitis, a select agent, with colleagues in Thailand and Australia will be subject to such oversight. Monath fears that U.S. researchers might be held criminally responsible for violations by collaborators. When he raised this issue with Strickland at the ASTMH meeting, he says, it was apparent that "NIH had neither thought about this nor had any clear response."

NIAID officials say they are simply in step with the times; later they plan to adopt standards being developed by the World Health Organization. "We will do what we can to ensure that every possible avenue has been pursued that will allow our NIH-funded researchers to be able to conduct their research safely and securely," the officials say. Much of that work, it appears, may well have to be done inside U.S. borders.

–RICHARD STONE

Earthquake Preparedness

Some Countries Are Betting That A Few Seconds Can Save Lives

Japan, Mexico, and Taiwan are investing in early warning systems that can offer precious seconds of warning before a major tremor

TOKYO—What would you do with 5 to 50 seconds' warning of a major earthquake?

It's not an academic question. Systems that can detect earthquakes near their source and issue warnings before the shaking starts are in place or being deployed in Mexico, Taiwan, and Japan and are being studied for locales from southern California to Istanbul. Enthusiasts are convinced that short-term warnings can save lives by stopping trains before they pass over damaged track, emptying out elevators, and alerting rescue units. "It is an epochmaking" advance in earthquake safety, says Masato Motosaka, a Japanese earthquake engineer at Tohoku University in Sendai.

On alert. Nowcast stations are being installed across Japan.

Not everyone agrees, however. Skeptics note that warning systems don't provide enough time to reduce casualties close to the epicenter of an earthquake. They also worry that such systems could divert spending from earthquake preparedness, which they say has the potential to do much greater good. "Warnings only help in some cases," says Robert Olshansky, an urban planner at the University of Illinois, Urbana-Champaign. "Investing too much of one's money and hopes in a short-term warning system is a distraction from the hard and less sexy work, such as upgrading older structures, that is really needed to improve seismic safety."

Faster than a speeding S wave

Early warning systems are not forecasts. Instead, they detect actual quakes near their source and issue warnings to automated systems and humans up to several hundred kilometers away. They work because electronic signals transmitted through wires or air travel faster than seismic waves moving through the earth. Warning schemes also take advantage of the two types of seismic waves that are generated when a fault ruptures. The first—and faster moving—primary (P) waves radiate directly outward from the epicenter. The secondary (S) waves, which cause the oscillating motions responsible for the most damage, lag by tens of seconds over a distance of a few hundred kilometers. "The P waves carry information; the S waves carry energy," explains Hiroo Kanamori, a seismologist at the California Institute of Technology (Caltech) in Pasadena. Unfortunately,

CREDITS (TOP TO BOTTOM): C. GOLDSMITH/CDC; JAPAN METEOROLOGICAL AGENCY

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P waves and S waves would arrive almost simultaneously near the epicenter, making warning impossible where shaking is most intense.

Farther away from the epicenter, there is time to analyze the signals and automatically generate warnings. After the October 1989 Loma Prieta earthquake in California, the U.S. Geological Survey (USGS) deployed a temporary array of three seismometers that warned workers demolishing a collapsed highway viaduct in Oakland about aftershocks. The system gave workers 23 seconds' notice of S waves from 12 aftershocks stronger than magnitude 3.7.

Two permanent early warning systems were put in place in the early 1990s in Mexico and Japan. In 1991 the Centro de Instrumentacion y Registro Sismico (CIRES), a private Mexican nonprofit organization, set up a network of 12 instruments along the country's Pacific coast near Acapulco, where seismologists think a magnitude 8 earthquake is overdue. If the system works as intended, residents of the capital city, 280 km away, could get 70 seconds' warning. Schools and some government offices are serviced by dedicated transmission lines, and citizens have access to automated radio broadcasts. Two years ago, a similar system was set up for the city of Oaxaca, in southern Mexico.

Likewise in Japan, the country's early warning systems are likely to prove most useful for the most devastating earthquakes, those that occur off the Pacific coast where the North American plate is being forced under the Philippine plate. For example, Motosaka says that the Sendai area would receive 15 seconds' warning that the effects of a magnitude 7 to 8 offshore earthquake were about to hit; seismologists give such an earthquake a 40% chance of occurring in the next 10 years.

In 1992, railway operators started deploying the Urgent Earthquake Detection and Alarm System (UrEDAS) along the country's bullet train lines. After detecting P waves, UrEDAS cuts power to trains in nearby sectors if the anticipated shaking will exceed a given threshold. In February, the Japan Meteorological Agency began deploying what will be the world's most comprehensive early warning system, featuring more than 200 stations throughout the four main islands. Installation of the $90 million network, called Nowcast, began in 2003 and could be completed in 2 years if the money keeps flowing. In December 2000, Taiwan's Central Weather Bureau switched on an islandwide network of 86 seismic stations that alerts the bureau's central office and a hospital, both in Taipei.

Authorities are still trying to figure out the best way to use early warning systems. Officials at Taiwan's weather bureau receive warnings on their computer screens, "allowing staff to move to disaster response stations a few seconds quicker than if they wait for the shaking to start," says Yih-Min Wu, a seismologist at the National University of Taiwan involved in setting up the system. Taiwan's high-speed rail line will likely be added to the system once train service begins next fall.

Japan's system, partially operational, sends warnings to a select group of regional disaster response centers, private companies, an elementary school, and a university hospital in the Tohoku region northeast of Tokyo. Tohoku University's Motosaka, who is leading a government study of potential warning uses, says earthquake education and drills can be worked into the school curriculum, as is now being done at the Nakamachi Elementary School in Sendai. Pupils have been taught to duck under their desks to avoid falling ceiling tiles and lighting fixtures, and teachers to open doors so they don't jam shut and hinder a postquake evacuation. In a hospital, the warnings could allow surgeons to pause during delicate procedures and give rescue teams extra seconds to prepare.

Three Warning Systems

TAIWAN

Early Warning System (completed 2000) works for the entire island. Cost: $930,000

MEXICO

Seismic Alert System (completed 1991) warns Mexico City of a major quake near Alcapulco. Cost: $1.2 million

JAPAN

Urgent Earthquake and Detection Alarm System (completed 1992) was established to slow or halt bullet trains after an earthquake. Cost: Not available

Nowcast (partial operation in 2004) was developed as a general seismic warning system. Cost: $90 million

Call ahead. Early warning systems could save lives in elevators and operating rooms.

CREDITS (TOP TO BOTTOM): GARETH BROWN/CORBIS; JUPITER IMAGES

The list of possible applications is endless, says Thomas Heaton, a Caltech earthquake engineer and longtime proponent of early warning systems. It includes switching all traffic lights to red, closing valves in oil and gas pipelines, shutting down nuclear power plants, and preparing tsunami warnings. "I don't think anybody knows right now what all the potential applications will be," says Heaton.

One unresolved issue is whether to broadcast warnings to the general public. The Mexican system has generated 11 warnings of strong (magnitude 6 or greater) earthquakes in 14 years without a hitch, according to Juan Espinosa-Aranda, director general of Mexico's CIRES. "Contrary to what many expected, we have never had any indications that the warnings resulted in panic," he says. Part of the reason, says Heaton, may be their benign content: "Ninety percent of the time, the message will be 'This will be light shaking, relax and enjoy it.'"

Without warning

To date, the payoff from early warning systems is scant, proponents admit. In 12 years, operators of Japan's UrEDAS can cite only one case in which the warning headed off a potentially dangerous situation. That occurred in May 2003, when a magnitude 8 earthquake struck northeast of Tokyo: The system halted two trains headed toward a viaduct that had suffered cracks in 23 columns.

In contrast, a bullet train derailed during the country's most recent severe earthquake, on 23 October in Niigata Prefecture, because the train was too close to the epicenter for a warning to arrive in time. Likewise, no early warning system would have mitigated the devastating 1995 Kobe earthquake, which claimed 5000 lives, because the fault that ruptured runs right under the city. "Warnings don't work" in such cases, admits Motosaka.

That fact of life, say scientists, means early warning systems should never replace seismic preparedness. "We need to spend money on mitigation and preparedness," says the University of Illinois's Olshanky. "Making promises of prediction or warnings distracts from this task."

Skepticism about earthquake warnings seems greatest in the United States, in part because the most dangerous faults are close to urban areas. Caltech's Heaton says that federal agencies have rejected several of his proposals to test a prototype early warning system for southern California after they received mixed reviews. "Half the reviewers said it was a great idea, and the other half said it's not very useful," he says.

To find out who's right, seismologists need hard data. Although they don't wish for misfortune, they know that earthquakes are inevitable. And they are counting on Mexico, Taiwan, and Japan to serve as test beds.

–DENNIS NORMILE