

► delivers neutron beams to dozens of instruments that have to be regularly upgraded to keep the facility globally competitive. With each upgrade costing between €3 million and €6 million, staying on the cutting edge eats up a significant chunk of the facility's €88-million annual operating budget. India will bring hardware and an extra €1 million or so per year in cash.

CRUCIAL PARTNERS

The desire to fund entirely new facilities provides an even stronger motivation for inviting outside partners. Beatrix Vierkorn-Rudolph, who oversees large research facilities at the German Federal Ministry of Education and Research in Bonn, says that without support from Russia and India, FAIR could not have gone ahead. The facility's Russian-born director, Boris Sharkov, adds that FAIR is in negotiations with China, Brazil and Saudi Arabia about possible collaborations, which could help to fund new particle detectors.

Brazil's admission into ESO will be crucial in paying for that organization's next-generation telescope, the 40-metre European Extremely Large Telescope (E-ELT). Around one-third of the €1.1-billion construction budget will come from Brazil's membership dues, says Tim de Zeeuw, director-general of ESO.

The new members get plenty in return, benefiting from the prestige associated with international collaborations and the training offered to their scientists. "ESO facilities are the top of the line," says Sergio Machado Rezende, a physicist at the Federal University of Pernambuco in Recife, Brazil, and the country's science minister from 2005 to 2010. ESO's best telescopes are located in nearby Chile, which made joining the organization even more attractive, he says. Brazil's astronomy community is currently made up of only about 200 researchers,

but Rezende says that involvement in ESO will help the community to grow and gain strength. Brazil's robust economy means that the nation will probably also consider involvement in organizations such as CERN, he says.

India's membership of FAIR should provide benefits for the country's technology firms, says Subhasis Chattopadhyay, a scientific officer at the Variable Energy Cyclotron Centre in Kolkata. The companies will supply power converters and magnets for the facility, and so gain expertise in constructing these hi-tech instruments. "Our goal was to get Indian industry building many new things," says Chattopadhyay, adding that India, too, has its eye on CERN.

Not every organization is looking to expand beyond Europe. "For the time being, there are really zero discussions," says Frederic Nordlund, acting head of international relations at ESA in Paris. His agency works closely with many nations, including Russia and India, but most want to maintain domestic expertise in space

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technologies, in part for strategic reasons.

ESA has a long-standing partnership with Canada, but the agency's current plans for expansion involve only new European Union member states. The European Molecular Biology Laboratory (EMBL) in Heidelberg, Germany, stands apart for different reasons. "EMBL isn't an organization that grows by building mega-projects," says Iain Mattaj, director-general of the organization. As a result, it has no plans to open itself formally to outside membership — although it did allow Australia to join as an associate member in 2008.

Those that are expanding recognize that the move comes with risks. Some fear that a growth in international membership could erode the

quality of European science or make it more difficult to govern. But Harrison says that European nations already on the ILL council are careful to ensure that any new members have a strong scientific community ready to use the facility. "We would not be interested in a member country that is rich but did not have the kind of user base that we could work with," he says.

SUSHI SURPRISE

Things could get complicated if Europe's centralizing instincts were to lead it to consolidate facilities — merging ESA and ESO, for example, or combining all of Europe's particle-physics facilities. Although such mergers are not likely in the short term, the presence of many non-European partners would hamper them in the future, says Carlo Rizzuto, chairman of both the board of the Elettra Laboratory near Trieste, Italy, and the European Association of National Research Facilities. But ultimately, Rizzuto thinks, more international members will only strengthen Europe's facilities, and its science. "If you get the best players, then you develop the best facilities," he says.

Heuer hopes that the CERN council's membership will grow from 20 to around 26 in the next 5–6 years. At the same time, he stresses that the lab must maintain its European character of careful deliberation and consensus-building, which is one reason that new partners must first join as associate members. Heuer predicts that CERN will adapt smoothly, given that it already hosts many scientists from outside Europe. As he points out, the lab's cuisine has already begun to diversify: "The cafeteria also sells sushi, by the way." ■

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2. Catanzaro, M. *Nature* <http://dx.doi.org/10.1038/nature.2012.10242> (2012).
3. Mann, A. *Nature* **469**, 451–452 (2011).

DISASTER PREPAREDNESS

Tsunami simulations scare Japan

Updated risk assessment warns country to prepare for much larger earthquakes and waves.

BY DAVID CYRANOSKI IN TOKYO

Japan's government is heeding a key message from last year's Tohoku earthquake and tsunami: the underwater faults that encircle the country can unleash much greater devastation than previously anticipated. Last week, the cabinet's disaster-management division briefed local officials on simulations that raise the spectre of waves even larger and more destructive than those last March, sending the officials scrambling to rethink their tsunami defence plans.

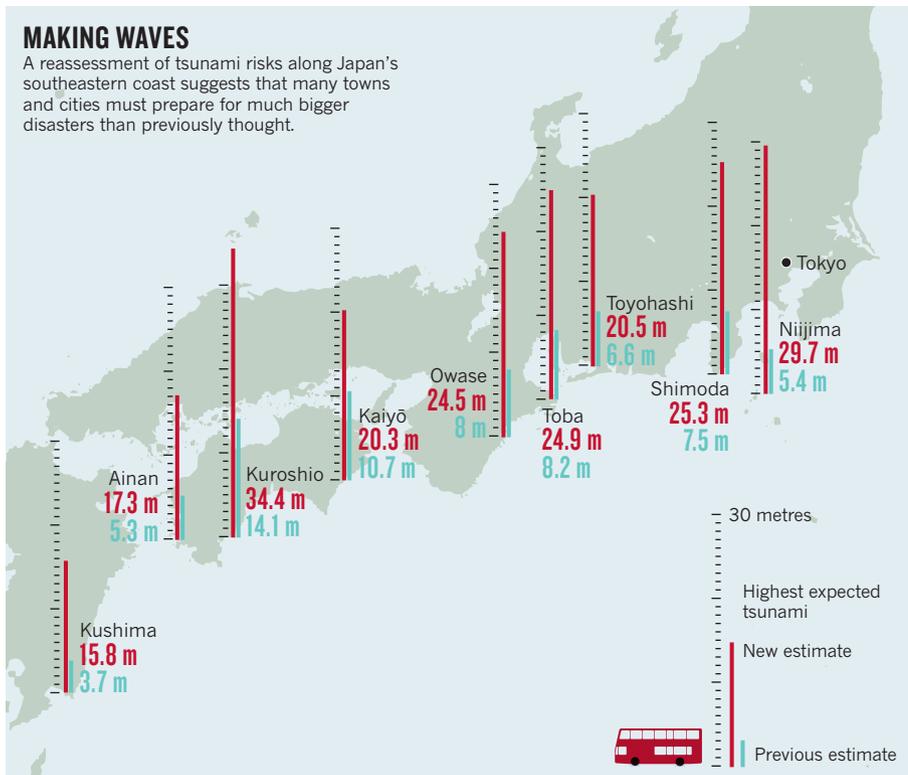
The estimates come from a government-appointed team of scientists led by Katsuyuki Abe, a tsunami expert and emeritus professor of the University of Tokyo. The team updated the nation's main tsunami model by increasing the magnitude of the largest expected earthquake to incorporate recent massive quakes, including the magnitude-9.0 Tohoku and the magnitude 8.8 that hit Chile in 2010, causing a tsunami that reached as far as Japan. The result: for most locations, the size of future tsunamis could far outstrip previous estimates, which were made

in 2003. The town of Kuroshio in Kōchi prefecture was steeled for a maximum 14.1-metre wave; it now faces the threat of a 34.4-metre inundation. Likewise, the offshore island of Nijijima has to prepare for a 29.7-metre wave, rather than 5.4 metres (see 'Making waves').

Ninety cities and towns must consider how to withstand a tsunami wave of higher than 10 metres, whereas just ten locales were expecting this from the older simulations. Twenty-three have been told to prepare for a tsunami of 20 metres or more, a threat none had previously

MAKING WAVES

A reassessment of tsunami risks along Japan's southeastern coast suggests that many towns and cities must prepare for much bigger disasters than previously thought.



anticipated. The team also raised the estimates of the risks posed by the largest earthquakes, with the number of towns and cities expecting the maximum level of ground shaking — 7 on Japan's intensity scale — raised from 35 to 153.

The reappraisal focuses on the Nankai trough, an offshore fault south of Honshu, Japan's main island, that regularly produces large quakes, including the magnitude-8.7 Hōei quake of 1707 that set the ceiling for the 2003 estimates. The latest simulations use the Tohoku quake, which was roughly three times more powerful than Hōei, as the maximum. They also take account of recent studies that used the thickness of sediment layers deposited by past tsunamis to estimate the size and frequency of major earthquakes and tsunamis that happened before accurate measurement methods existed. The 2003 models, which predicted much smaller tsunamis than those that followed the Tohoku earthquake, have been criticized for not including such sedimentation data (see *Nature* 483, 141–143; 2012).

The updated model also considers 'large slip' areas, in which extensive crust movement can make parts of tsunamis particularly hefty. Such areas were to blame for the unexpected high waves in parts of Japan last year. The team considered how coastal regions would be affected in 11 tsunami scenarios, each of which had large slip areas in different places along the Nankai trough.

Magnitude-9 events are expected to occur very rarely, perhaps once every millennium, says Kenji Satake, a tsunami expert at the University of Tokyo and a member of the team that updated the models. How much preparation

is needed for such rare, devastating events remains a matter of debate, but the models have put local governments in a tight spot. Yukihiro Nakamura, head of earthquake preparedness in the Kōchi prefecture, says that the briefing was not detailed enough to give administrators a clear path forward.

"We need to know how high the water will come at different points. Will it be 34 metres everywhere?" The government has promised a fine-grained simulation and inundation maps that detail water levels by the end of May.

Even that information may not help officials to determine how to prepare for such devastating events. Some towns are installing additional loudspeakers to warn citizens of an approaching tsunami, but they might give no more than a few minutes' warning. Nakamura says it is unreasonable to think that people could seek shelter — by climbing evacuation towers tens of metres tall, for example — within that time.

Officials in some regions are also making plans to move city offices to higher ground, and considering measures such as building large underground shelters or relocating large numbers of homes — both of which are costly options that are beyond the capacity of local or prefectural governments. A cabinet working group is discussing how the central government could help.

Before last year's devastating earthquake, "we had been preparing for a magnitude-8 quake they said would have 60% chance of coming in the next 30 years", says Nakamura. "But after Tohoku, we have to be prepared for the unexpected, too." ■