Other possible sites include Dubna, Russia; Fermilab in the US; and Japan. As to whether the US would like to host the future linear collider, Dennis Kovar, the US Department of Energy (DOE) associate director of science for high-energy physics, says, "Out of context, yes, of course. In context, it's more complicated." A lab such as CERN could still manage the new machine if it's built somewhere else. Or on site, CERN, Fermilab, or the KEK research institute in Japan could act as landlord—being responsible for safety and other issues but not the actual collider.

Another option for the legal status would be to create a treaty organization from scratch. That has its own difficulties, as demonstrated by the more than two decades it took to form ITER (the international fusion energy test reactor). Or a limited liability corporation could be created with the member countries as stakeholders. In a report presented in early June to the US High Energy Physics Advisory Panel, the linear collider steering group of the Americas writes that as far as legal status, the "most desirable will be an instrument that . . . maximizes the incentive of the parties to complete the project on an agreed upon schedule; provides ready access for the international staff . . . and users; [and] provides tax free access to equipment and materials for construction and operation of the facility."

Who pays for operations is a likely sticking point. Until now, the host country has always paid the power bill—a significant cost—for the main accelerator, while users typically cover the cost of running their detectors. That model works in a world with big facilities on each continent, as envisioned by the current guidelines of the International Committee for Future Accelerators. But, says the University of Oxford's Brian Foster, the European director for the ILC, "As you get to fewer installations, that averaging out fails to work. We need to address that." Alternatives range from the host country's paying the operating costs in full to countries paying in proportion to their numbers of users. "It's premature to decide," says Foster.

More generally, Foster says, "We are trying to avoid the mistakes which we can identify in current projects and [which] have been made by past ones. We are looking at big international projects—above $1 billion."

One lesson is to ensure that countries' cash contributions are enough to give the project flexibility. Pointing to the high level of in-kind contributions as a major cause of ITER's troubles, Foster says that a minimum of 20% of the total budget should be cash. Another lesson is to avoid delays that would result from needing approval of a governing council—which meets infrequently—by giving the project director the authority to make most decisions. But, notes Foster, "until you have a host site, all of these governance issues are rather abstract."

A balancing act

A problem that goes along with having fewer, bigger machines is how to keep national or regional accelerator- and particle-physics programs vibrant enough to attract new talent. There is talk about each region becoming preeminent in a particular field; for example, Europe could be host to the high-energy frontier, and the US and Asia could focus on the intensity frontier, such as intense proton beams to create neutrinos and muons, or on astroparticle physics—the "cosmic frontier." Another model is for regions to sequentially host big machines. None of those models holds wide appeal, however.

"In a nutshell," says Nobu Toge, a KEK accelerator physicist and member of the ILC global design effort, "each one of us prefers to have [the future machine] in his neighborhood for physical or economic or political motivations. Of particular importance are the issues associated with domestic education and training of younger generations, which have wide-ranging implications for our societies."

Everyone, says Kovar, is struggling with the questions, "How do we go forward in a way that countries can contribute in an equitable way to facilities and research that is going to advance the field? How do we keep facilities open for all scientists from any country? How do we make investments so that everyone feels they are bearing a fair share? And how do we do it in a way that we also preserve national programs, and the benefits can be demonstrated to taxpayers?"

Toni Feder

Obama's nuclear weapons agenda is on multiple rapid tracks

Nonproliferation moves to the top of the president's priority list; a new arms treaty with Moscow, a summit on nuclear security, and a UN disarmament conference cap a nuclear spring.

With the unanimous approval of their report, the 189 member nations of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) adjourned their month-long treaty review conference at the United Nations on 28 May. Although its accomplishments were modest and arguably more symbolic than substantive, that it had produced a consensus at all was remarkable, given the participation of Iran, which the US and its allies insist is developing nuclear weapons in violation of the NPT.

But for the Obama administration, the treaty review capped an extraordinary year of ferment in US nuclear policy, involving an unprecedented degree of participation from the highest ranks of government. The signing of a new arms control agreement with Russia on 8 April was followed by a multibillion-dollar commitment of new resources to nuclear weapons R&D and maintenance and then by a major revision of the policy governing the use of US nuclear forces.

The newest policy revision—the nuclear posture review, ordered by Congress in 2007—is the third revision, but the first to be unclassified in its entirety. It narrows the circumstances under which the president can order a nuclear attack. In particular, it rules out use of the weapons against any nonnuclear weapons state that is meeting its NPT obligations.

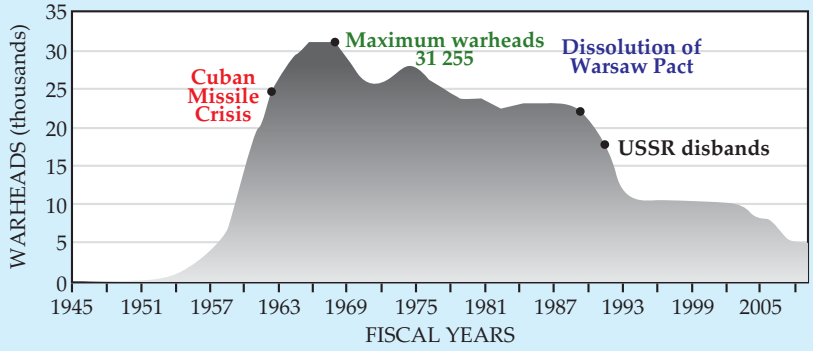
In further support of President Obama's mantra of openness and transparency, the number of nuclear warheads in the US stockpile—5133 as of 30 September 2009—was declassified for the first time ever. In a speech to the 3 May opening session of the NPT review conference, Secretary of State Hillary Clinton announced the figures, which included historical stockpile levels and the numbers of weapons that have been dismantled. "The threats of the 21st century cannot be addressed with a massive nuclear stockpile. So we are taking irreversible, transparent, verifiable steps to reduce the number of nuclear weapons in our arsenal," Clinton said.

The declassified numbers show a current stockpile that is one-quarter of what it was in 1989, when the Berlin Wall fell, and 84% smaller than its peak of 31 255 warheads in 1967 (see the chart; also see the article by Sid Drell on page 30). The numbers of deployed warheads—mounted to their missile delivery systems or to bombs ready to be loaded onto aircraft—have declined

from 10 000 in 1991, when the Soviet Union was dissolved, to just 1968 at the end of 2009, according to the State Department. Other weapons are maintained in the stockpile in various states of readiness and for use as spares. The administration also revealed that 8748 warheads were dismantled from 1994 to 2009. Several thousand more weapons have been retired from the stockpile and are awaiting dismantlement.

"The stockpile numbers and unclassified [review] are important on the international stage because they enable allies and adversaries to better understand the US nuclear posture," says Hans Kristensen, a nuclear weapons expert at the Federation of American Scientists who has estimated warhead numbers over the years—with great accuracy, as it turns out. Showing the dramatic reductions since the cold war, the numbers also provided evidence needed for the NPT review conference, he adds.

US nuclear weapons stockpile, 1945–2009*



*Includes active and inactive warheads. Several thousand additional warheads are retired and awaiting dismantlement.

US nuclear weapons numbers revealed. Declassified data show the US nuclear stockpile peaked in the late 1960s. As seen in the feature article on page 30, the Soviets continued building their arsenal for nearly a decade more.

Slogging toward disarmament

In the conference's most tangible achievement, the NPT nations agreed to reconvene in 2012 to begin discussions on freeing the Middle East from weapons of mass destruction. That goal had been proposed at a treaty review conference 15 years ago, but no headway was achieved until now. In that context, treaty members this year called on Israel, one of just three nations that never signed the NPT, to accede as a non-weapons state. Israel, the only nation in the region thought to possess nuclear weapons, quickly condemned the language. The US voted for the conference report, while deploring the provision and promising that it would protect Israel's interests at the 2012 session.

White House national security adviser James Jones called the remainder of the 28-page NPT report "balanced" and said it contained "practical steps to advance nuclear disarmament, nonproliferation, and peaceful uses of nuclear energy, which are critical pillars of the global nonproliferation regime." Jones also praised the report's pledge to strengthen the authority of the International Atomic Energy Agency to verify compliance with the treaty.

Daryl Kimball, executive director of

the US nonprofit Arms Control Association, declares the conference "a surprising success, in that the countries came to a consensus on a final, forward-looking action plan." That 64-step blueprint calls for further arms reductions, including of tactical weapons; urges prompt ratification of the Comprehensive Test Ban Treaty by the US, China, and other holdouts; calls for negotiations to begin immediately on a treaty to ban all production of fissile materials; and instructs the weapons states to pare their reliance on nuclear forces for their national security. Each element has the support of the Obama administration, Kimball notes.

Kristensen says the 2010 review was a marked improvement from the last review, when no consensus was achieved. Further progress on arms reduction, he says, will hinge on continued US leadership toward the NPT's ultimate objective of global disarmament, a goal that Obama embraced in an April 2009 speech in Prague, Czech Republic. Article VI of the NPT obligates the US and the four other nuclear weapons state signatories—Russia, China, France, and the UK—to disarm, although, as Obama has acknowledged, the US is unlikely to give up its weapons during his lifetime.

Rebecca Johnson, director of the London-based Acronym Institute, blames the weapons states for thwarting "a strong collective will among the vast majority of [NPT] members" for accelerating disarmament. The 118 developing nations that make up the Non-Aligned Movement had proposed that a more comprehensive treaty be negotiated to replace the NPT, which in their view has perpetuated the status quo of nuclear haves and have-nots, Johnson notes. As it is, the review document, steering clear of any mention of a timetable, did little to firm up the nuclear powers' vague commitment to disarm someday. And a small but determined group of nonnuclear states successfully fought back attempts by the US and others to make it mandatory for the nonweapons states to adopt more rigorous inspections and verification procedures known as the "additional protocol," which 139 member states have voluntarily adopted.

New life for weapons labs

Reflecting the rising importance to the US nuclear deterrent that each individual warhead will play in the downsized stockpile, the weapons labs and weapons manufacturing plants are to receive billions of additional dollars in the years ahead. Defense Secretary Robert Gates told lawmakers in May that he had sought for more than three years to have $4.8 billion of the Pentagon's budget transferred to the Department of Energy's National Nuclear Security Administration (NNSA) over a five-year period. With the fiscal year 2011 budget request, the White House heeded his pleas, proposing a 25% increase for weapons R&D and for maintaining, monitoring, refurbishing, and dismantling the weapons.


CHERIE CULLEN, DOD

Nuclear policy unveiled. Administration officials briefed the media on President Obama's new weapons policy, known as the nuclear posture review, at the Pentagon on 6 April. From left, Joint Chiefs of Staff chairman Admiral Mike Mullen, Secretary of Defense Robert Gates, Secretary of State Hillary Clinton, and Secretary of Energy Steven Chu.

"By modernizing our aging nuclear facilities and investing in human capital, we can substantially reduce the number of nuclear weapons we retain as a hedge against technical or geopolitical surprise, accelerate dismantlement of retired warheads, and improve our understanding of foreign nuclear weapons activities," the nuclear posture review report states. The document reaffirms the science-based approach to maintaining the nuclear stockpile, in which experimental efforts such as the National Ignition Facility, in combination with ever more powerful computer simulations, can predict what changes will occur as the weapons age and whether those changes will affect the weapons' safety and reliability.

The Obama nuclear posture review also makes nuclear nonproliferation the top priority of US nuclear weapons policy, a promotion that is reflected in the 26% funding increase that the president has requested for the NNSA's nonproliferation programs for FY 2011. And the document breaks new ground by declaring that US nuclear warheads will never be used against nonnuclear weapons states that are in compliance with the NPT—even if such a country were to use a chemical or biological weapon. In that case, the review report instead promises "a devastating conventional military response."

But Obama's review disappointed some advocates of nuclear disarmament by not forswearing the first use of nuclear weapons in a conflict with other nuclear weapons states, as China and even North Korea have promised. Instead, the report cites a "narrow range of contingencies" in which a credible threat of a US nuclear strike is necessary to deter a conventional, chemical, or biological strike against the US or its allies.

Linton Brooks, who headed the NNSA during much of the George W. Bush administration, says the latest nuclear posture review process included greater participation from the Department of State and other agencies outside the Department of Energy and the Pentagon. Far more input was provided by cabinet-rank officials, in comparison to posture reviews during the Bush and Clinton administrations. "There is no question in my mind that Gates has been a major force" in the NPR process, Brooks says, adding that Gates's predecessor, Donald Rumsfeld, "had different priorities."

But Brooks warns that two new big-ticket nuclear facilities, a plutonium fabrication plant at Los Alamos National Laboratory and a uranium processing facility slated for the Oak Ridge Y-12 plant, could eat up most of the new resources proposed for the NNSA. Such one-of-a-kind nuclear facilities have a long history of substantial cost growth, he warns. The real question for the labs, he says, is whether the budget increases will be sustained after 2011, given increasing alarm over federal deficits.

Brooks, who led the US team that negotiated the 1991 arms-reduction treaty, says that the New START accord signed by Obama and Russian president Dmitry Medvedev in April is "absolutely supportable" by the nuclear posture review. The two nuclear superpowers agreed to a cap of 1550 strategic warheads each and to limits on missiles, bombers, and ballistic submarines. The treaty does not constrain the US from deploying missile defenses, and Gates and Clinton have dismissed pronouncements to the contrary by Russian officials.

Brooks says the New START is far

more important for the improvements it will make to transparency and for its simplified verification procedures, compared with its predecessor. "This is a treaty on training wheels to get us back in the treaty business," he says. "It's about showing we and the Russians can work together on something complex and contentious."

Although further reductions in the US stockpile are likely, the US must plan them carefully to ensure that a credible deterrent force is maintained, cautioned Stephen Younger, a former senior associate director at Los Alamos. In remarks at an NNSA-sponsored conference, Younger said that at some level—perhaps 100 warheads—an enemy might be tempted to launch a preemptive attack, calculating that it can "ride out" whatever retaliatory strike the US can muster with its remaining strategic weapons. Younger, currently president of the contractor that operates the NNSA's Nevada Test Site, said a litany of technological challenges will first have to be met to ensure compliance with a global ban. And then there's the diplomatic challenge of persuading unwilling nuclear weapons nations to disarm.

A nuclear summit

Just days after the New START treaty signing in Prague, Obama hosted a nuclear security summit that brought a record number of world leaders to Washington in a show of support for his vision to secure within four years all of the estimated 2000 tons of separated plutonium and highly enriched uranium (HEU) scattered around the world. Nearly all the 47 leaders participating at the summit brought with them a recent accomplishment or commitment to lock up fissile materials. Chile, Kazakhstan, Mexico, and Vietnam promised or reiterated previous pledges to send the HEU that fuels their research reactors back to the nation of origin—the US, Russia, or China—and trade it in for low-enriched uranium.

Other countries agreed to install radiation monitors at ports to help detect nuclear smuggling. Russia used the occasion to officially shut down for good its last plutonium production reactor, which doubled as an electrical generating station. The US touted a recently completed HEU materials facility at Oak Ridge that consolidates under one roof the US stockpile of HEU that had been spread around the site in a number of World War II–era warehouses.

Gary Samore, White House coordinator for weapons of mass destruction, counterterrorism, and arms control, told reporters at the summit's conclusion to expect more remarkable achievements to be announced at a second summit in Buenos Aires, Argentina, this fall. "Physical protection is something that governments and industry know how to do if they invest the resources," Samore said. Progress continues in the meantime: On 9 June, the NNSA announced a new agreement with the government of Croatia to equip the Balkan nation's seaports, airports, and border crossings with radiation detectors and to train operators to use and maintain them.

David Kramer

Airport checkpoint technologies take off

From bench-top instruments to full-body scanners, the US government is testing new equipment to screen humans for explosives.

In the wake of the failed attempt in December 2009 to bring down a Northwest Airlines flight with powder explosives, the US Transportation Security Administration (TSA) has accelerated the revamp of its airport screening technologies. Armed with funds from the 2009 American Recovery and Reinvestment Act, TSA is spending $50 million on trace-explosives detection systems, $22 million on liquid-explosives scanners (see story on page 28), and $73 million on controversial full-body scanners, which might have revealed the explosives knitted to the December suspect's underwear.

So far, TSA has installed more than 95 full-body scanners, at about $160 000 each, in 31 US airports; it plans to deploy up to 450 by the end of the year and 500 more next year. Among the primary suppliers are California-based Rapiscan Systems, whose system generates images from backscattered x-ray radiation, and New York–based L-3 Communications, whose scanners generate images from reflected or scattered millimeter waves. Both systems take less than 10 seconds to screen one person, not including the time it takes a TSA agent to analyze the image.

The agency has been evaluating both technologies in airports since 2007. And their use and development date back