Challenges in national nuclear security need specific, viable solutions

The article by Pierce Corden and David Hafemeister (PHYSICS TODAY, April 2014, page 41) about nuclear proliferation and testing was interesting and useful. The authors appear to be overly optimistic, though, about the role of tags, seals, and radio-frequency identification (RFID) tags in verification. I have studied hundreds of tags and seals, including those used for nuclear applications, and I have seen no evidence that current tags and seals are useful beyond "security theater"—fake security for show. They cannot stand up to spoofing by resourceful hobbyists, much less by a nuclear state with substantial technical expertise and resources. Counterfeiting and tamper detection are largely unsolved problems, with remarkably little significant, innovative R&D under way.

Inexpensive kits available on the internet can help a person sniff, spoof, and counterfeit RFIDs, and RFID readers are typically easy to spoof remotely or by physically accessing them for a few seconds. Encryption doesn't really address the problems with RFIDs, given the ease of counterfeiting, tampering, and transferring them from one object or container to another.

The International Atomic Energy Agency does no meaningful background checks on its employees and nuclear inspectors. That lapse increases the risk that insider attackers might defeat even effectively designed tags, seals, RFIDs, and surveillance hardware.

The field of nuclear safeguards and treaty monitoring has long been plagued by wishful thinking and deployment of hardware and software that lack adequate security. The article by Corden and Hafemeister is not helpful in addressing the problem.

Roger Johnston
(rbsekurity@gmail.com)
Argonne National Laboratory
Argonne, Illinois

■ **The interesting article** by Pierce Corden and David Hafemeister misses a crucial issue in the discussion of nuclear nonproliferation treaties and their implementation.

President Dwight Eisenhower, in his famous 1953 "Atoms for Peace" speech and the Nuclear Non-Proliferation Treaty (NPT) that followed and codified it, did not directly address what the world should do about countries that do not sign the NPT, have withdrawn from it, or violate its mandates. The situation has gotten complicated largely because the US and the Soviet Union and its descendant states—the Russian Federation in particular—have failed to squarely address the matter.

Starting in August 1945, I and others who realized that the world now knew how to destroy itself assumed that assistance on peaceful nuclear issues and even financial help for nonnuclear power sources would be withheld from nations that did not sign onto or violated the NPT.

Neither the Soviet Union nor the US took action against nonsignatories India, Israel, and Pakistan, nor against North Korea, which former president Jimmy Carter encouraged not to withdraw from the NPT but which has violated it. That failure continues in our approach to Hassan Rouhani, president of Iran.

As a signatory of the NPT, Iran has no right to make nuclear weapons, but it does have a right to enrich uranium for peaceful purposes. If Iran withdraws from the NPT (after the required six months' notice), it will have as much right as any country to make nuclear weapons (rights that we would prefer they did not exercise)—even more than the US or Russia, nations that would still be bound by the NPT with an agreement to disarm. Rouhani basically asked the US to agree to those rights, after which Iran would be sensible and enrich uranium only for peaceful applications. By refusing to recognize the logic described above, we encourage countries to stay in the NPT, even when they ignore its dictates, instead of persuading them to be sensible.

The authority of the NPT is further complicated by the refusal of US politicians, and hence the public, to realize that disarmament in exact synchronism with the adversary is not necessary. Actually, the "side" that disarms first saves money by not having to maintain its extensive stockpile.

Physicists have the training to understand those issues. In fact, for many years the world blamed physicists for bringing them the atomic bomb and trusted physicists to know what they had wrought. Physicists still have an obligation and a duty to understand and explain those matters and not be content with a mere statement of the treaties. Their involvement should include helping colleagues in other countries explain to their government and people the importance of these issues. The future of civilization may well depend on us. Let us not fail the world again.

Richard Wilson
(wilson@physics.harvard.edu)
Harvard University
Cambridge, Massachusetts

■ **Corden and Hafemeister reply:** We are grateful to Roger Johnston and Richard Wilson for their comments. The applications of science and technology to nuclear nonproliferation and arms control are many; our article addressed only some of them. Tags and seals cannot stand alone in a verification system. We acknowledge that considerable care needs to be taken to deal with attempts to spoof them, whether from outside or by an "insider." We endorse Johnston's observation that further R&D is important. Johnston pointed out in 2001 that the integrity of tags and seals can be strengthened with technologies that include thin films, advanced polymers, liquid crystals, microparticles, electro-optic materials, nanotechnology, one-time key pads, and other approaches.[1]

Multiple signatures make tags and seals more robust. Clearly, some tags and seals that are more complex may be difficult for all International Atomic Energy Agency (IAEA) member states to accept. The US alone cannot dictate higher standards to the world, but it can work within the IAEA to upgrade safeguard technologies.

The concluding paragraph of our article briefly addresses the issues raised by Wilson on the lack of universality of the Nuclear Non-Proliferation Treaty (NPT), specifically with India and Pakistan and US foreign policies that have made reversing their nuclear programs more difficult. But it is not accurate to say that either state has not been subject to efforts to halt them over the years; for example, their economies were severely sanctioned by the US after their May 1998 nuclear tests.

The NPT is not a suicide pact. It speaks of the right to peaceful uses of

nuclear energy and makes no mention of a specific right to enrichment or reprocessing. We think that the efforts of the international community to strengthen the constraints on Iran against its acquisition of nuclear weapons are appropriate, and we hope for their success. As physicists who have spent much of our careers in nonproliferation, arms control, and disarmament, we agree with Wilson's point that the physics community should explain the policy implications of nuclear weapons issues. And working on resolving those issues is perhaps even more important.

Has the NPT process helped or hurt global proliferation? Certainly it initially enhanced technology transfer of plutonium manufacture, but it also gave the world a starting place to establish nonproliferation criteria and institutions to carry out inspections under the NPT and the IAEA. Further progress will make it easier to obtain nuclear technology, will lower the technical barrier to the bomb over time, and will increase the need for strong NPT and IAEA safeguards. And starting with the Carter administration in 1977, the US has worked mightily to constrain enrichment and reprocessing in non-nuclear-weapon states. A major concern is that the NPT is silent on the issue of ownership of the nuclear materials in states that withdraw from the NPT—North Korea, for example—and what to do about it. Problems are well known, but specific, viable solutions are needed.

Reference

1. R. Johnston, *Sci. Global Secur.* **9**, 93 (2001), p. 107.

Pierce Corden
(pierce.corden@yahoo.com)
American Association for the Advancement of Science
Washington, DC
David Hafemeister
(dhafemei@calpoly.edu)
California Polytechnic State University
San Luis Obispo

Shock waves and history in free fall

As I read with interest "Dynamics of a skydiver's epic free fall," the Quick Study by José Colino, Antonio Barbero, and Francisco Tapiador (PHYSICS TODAY, April 2014, page 64), I encountered several important errors from the aerodynamic standpoint that need to be clarified.

First, in the paragraph just above the subhead "A closer look at Baumgartner's jump," the authors state that "since the [shock] wave propagates at the speed of sound, the diver will eventually cross that disruptive shock." Shock waves always propagate faster than the upstream speed of sound. In fact, what we call a detached shock wave, which forms upstream of a blunt body flying at supersonic speeds, travels at roughly the same velocity as the blunt body itself.

Second, the authors state that "shock waves form where subsonic and supersonic flows meet." That is true only when downstream boundary conditions require that a supersonic flow slow to subsonic speeds. When a subsonic flow accelerates to a supersonic flow, the region where the flow is sonic is not a shock wave but a sonic line or sheet. Accordingly, the thin regions marked in blue in panel b of the figure are sonic sheets, not "shock waves" as the authors state. The sheets delimit the subsonic region between the shock and the diver's head, and the supersonic region around the chest and the rest of the diver's body.

Unlike shock waves, sonic sheets are isentropic. Of course, even though it is supersonic, the flow formed downstream of the sonic sheets marked in blue is slower than the incoming flow. Nevertheless, the unsteady and complex boundary layers formed around the chest and backpack wrapped in fluttering fabrics create a forest of small, low-intensity shock waves that eventually accommodate the air speed to that of the object in contact with it.

Furthermore, in describing panel b of the figure, the authors say the detached shock wave at the diver's front is positioned "downstream" of him. That turns the established language of fluid dynamics upside down: "Upstream" is in the opposite direction to the incoming flow relative to the object (or to the axes used to describe the motion), and "downstream" is behind the object, in the direction of the flow.

My above comments aside, I truly congratulate Colino and coauthors for their illuminating study on the free fall of a diver; I will surely use it in my undergraduate classes.

Alfonso M. Gañán-Calvo
(amgc@us.es)
University of Seville
Seville, Spain

■ **The lead-in paragraph** to the interesting Quick Study on Felix Baumgartner's free fall misstates history when it says that Baumgartner fell faster than anyone before him. In 1966 an SR-71 reconnaissance aircraft experienced an in-flight breakup while traveling faster