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Who Did It? Using International Forensics to Detect and Deter Nuclear Terrorism

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ARTICLE FOR ARMS CONTROL TODAY:

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By William Dunlop and Harold Smith

On February 2, the *New York Times* reported that the Pentagon has formed a nuclear forensics team tasked with identifying the terrorist attackers should the United States be hit with a nuclear bomb. Adapting nuclear technology to the forensics of exploded nuclear weapons is an old but rapidly evolving field. It dates back to at least 1949, when analysis of airborne debris, retrieved at high altitude off the coast of China, convinced President Harry Truman that the Soviet Union had exploded a nuclear device on the steppes of central Asia. The technology is neither new nor has it been particularly secret, but the formation of a national nuclear forensics team was newsworthy and a useful development. An international team, however, would be even better.

Although Washington has naturally focused on preventing a nuclear terrorism attack in the United States, a U.S. city is not necessarily the most likely target for nuclear terrorists. It is doubtful that a terrorist organization would be able to acquire a U.S. nuclear device and even more doubtful that it would acquire one on U.S. soil. Accordingly, if a terrorist organization does get its hands on a fission device, it is likely that it will do so on foreign territory. At that point, the terrorists will have an enormously valuable political weapon in their hands and will be loath to risk losing that asset. Given the risks associated with getting the device into the United States, the rational choice would be to deploy the device abroad against much softer targets. For Islamist terrorists, a major "Christian" capital such as London, Rome, or Moscow might offer a more suitable target.

Among these, Moscow perhaps presents the most compelling case for international cooperation on post-detonation nuclear forensics. Russia has the largest stockpile of poorly secured nuclear devices in the world. It also has porous borders and poor internal security, and it continues to be a potential source of contraband nuclear material and weapons, despite the best efforts of the Cooperative Threat Reduction (CTR) program. If terrorists obtained the nuclear material in Russia and set Moscow as their target, they would not have to risk transporting the weapon, stolen or makeshift, across international borders. Attacks by Chechen terrorists in Beslan and the Dubrovka Theater in Moscow offer ample proof that a willingness to commit mass murder for fanatical reasons rests within Russian borders, and a foreign source of operatives, particularly from the neighboring Islamic states to the south, is by no means inconceivable.[1] Moscow is also a predominately Christian city where local authorities routinely discriminate against Muslim minorities.

Furthermore, extremists might conclude that a nuclear blast in Moscow could inflict damage well beyond those directly stemming from the attack. The Soviet generation that came to power during the Cold War retained a memory of the United States as an ally in the Great Patriotic War. The present Russian generation has no such remembrance but seems to have retained the animosities and suspicions that were a part of the nuclear standoff. Hence, nuclear terrorists may well believe that they could cause another East-West cold war or even encourage Russia to retaliate against the United States. After all, the sinking of the Kursk was believed by some influential Russians to be the result of American action.[2] How much more likely would be such a view if the Kremlin were destroyed? As long as the world is filled with suspicion and conflict, such reactions are to be expected and, more importantly, anticipated.[3] One has only to remember the early reactions and suspicions in the United States following the 1996 TWA Flight 800 airline disaster.[4]

Because the United States is the technological leader in nuclear forensics, its capability will certainly be offered and probably demanded no matter what foreign city is subjected to the devastation of a nuclear explosion. The entire world, not just Americans, will live in fear of a second or third nuclear explosion, and forensics could play a vital role in removing or at least narrowing that fear. Because of such worldwide dread, there will be an international aspect to nuclear forensics regardless of where the explosion takes place. It would be better to be prepared in advance for such contingencies than to delve into the arcane world of nuclear weapons and radiochemistry on the fly.

Nuclear Forensics

The force of a 10 kiloton nuclear explosion on the streets of Moscow and the radioactive debris that would be deposited locally and ejected into the atmosphere could provide, over a period of time extending from hours to weeks, insight into various aspects of the weapon employed. For example, the international seismic community, assuming a surface burst, would have estimates within hours of the yield of the weapon. That measurement could be confirmed by examining the resultant crater using airborne or space borne photography or by knowing the distance at which windows withstood the force of the shock wave. Both would be known within hours and there would be little doubt that the explosion was nuclear; there is always the mushroom cloud, the symbol of the age.

The radioactive debris can provide far deeper insight. Over a period of a several weeks, laboratories throughout the world with access to the debris and the equipment and expertise to conduct the necessary measurements could address questions that would potentially shed light on the identity of the perpetrators. Among these would be whether the weapon was based on highly enriched uranium (HEU) or plutonium. Other questions that could be answered include:

1. If the weapon used HEU, scientists could determine the enrichment or share of the uranium 235 that it contained.
2. If the weapons used plutonium, scientists could determine how much time the fuel had spent in a nuclear reactor to create the appropriate plutonium isotopes, the length of time since this isotope was separated from spent nuclear fuel, and various isotopic signatures that might provide other indications of the production and separation processes.
3. The sophistication, or lack thereof, of the weapon Scientists could make this judgment based on the efficiency of the plutonium or HEU fission and whether fusion reactions might have been employed to enhance the yield.

If the isotopic data obtained from the debris could be compared with similar data from plutonium or HEU stockpiles or weapons, it might be possible, under some conditions, to conclude that some of the fissile material did or did not come from a specific arsenal. It might even be possible, given enough time and given access to actual weapons designs, to conclude whether a particular type of weapon had been employed.

Such determinations, if credibly obtained and distributed, could prove vital. If it were made clear, *a priori,* by established states, particularly the United States, that such forensics capability existed, that it would be employed anywhere in the world, and that the supplier of the nuclear material and/or weapon would be held responsible, nuclear forensics might deter potential suppliers. After an attack, nuclear forensics could be combined with other forensics methodologies and information tying involved individuals o places and events. Together this data could help establish the route from the supplier to the user and perhaps facilitate elimination of the supply chain. Furthermore, because the samples that might be collected are very small and have a mixture of isotopes with short, medium and long half-lives[5], a significant amount of time, measured in days, is needed before the presence of some isotopes with longer half-lives can be measured with certainty. Hence, the time required to make some of these key determinations imposes a temporary moratorium on potentially catastrophic reactions by political leaders, who can legitimately inform their constituencies that appropriate action must wait until the evidence is clear.

Although the technical challenge to fielding an international nuclear forensics team is considerable, and the benefits to the international community seem incontrovertible in the era of nuclear terrorism,, the political and diplomatic obstacles are enormous, perhaps overwhelming. The world community may for the moment have to be satisfied with a few seemingly small steps that could be vital in setting the stage for an international undertaking of critical importance.

Access to Debris

Unlike the reactor accident in Chernobyl, where the debris drifted northward, the narrow plume of measurable, radioactive debris, emanating from an explosion in Moscow would probably drift slowly to the east and would not cross the Russian border until it reached Kazakhstan approximately 24 hours later. Conceivably, the Russian government, if it chose, could deny access to the debris for that period of time, during which it could make its own measurements and determinations and could withhold the information. In all likelihood, such a policy would fail for several reasons:

1. Russian scientific capability is widespread and sophisticated, particularly in Moscow and its environs. Unauthorized measurements by knowledgeable scientists in Russian laboratories would be eagerly sought and propagated by a hungry press.
2. If the explosion were near the Kremlin, the U.S. embassy in Moscow would be damaged, perhaps severely, but there would be survivors who would be evacuated to the United States, possibly carrying samples of debris with them.
3. Foreign experts might have access to the debris as it crossed into Kazakhstan approximately a day or so after the event. Certainly, the government of Kazakhstan would have access, and given the degree of nuclear testing that has been conducted in that country, one would have to presume that forensics expertise and equipment would be available.
4. It might be possible for the United States or other country to fly over Russian soil to obtain airborne samples of the debris. It is uncertain whether the United States or any other country would mount such a politically risky operation.
5. The Russian government would also have to worry that foreign governments might conduct clandestine operations on its soil.

Given these considerations, it would be foolish for Russia or any other targeted nation to deny foreign access to the debris. The interests of the attacked country would be better served by inviting international expertise to participate in the forensic examination.

Access to Stockpile Data
Foreign access to the debris is one thing; access to stockpile data for purposes of comparison is quite another. Even if Russia or another country were attacked, current diplomatic realities make it unlikely that a government would grant foreign experts access to relevant stockpile data. In the Russian case, one suspects that the Kremlin would choose to treat the problem as a Russian problem at least until the source were known to them, a period of time ranging from a week to several weeks to an indefinite future. In the interim, if they so chose, Russia would be free to inform the international community of their suspicions.

Ideally, the nuclear powers, operating under the aegis of the International Atomic Energy Agency (IAEA) or the Comprehensive Test Ban Treaty Organization (CTBTO), would form an international team of nuclear forensics experts. The IAEA seems to be the better choice for a variety of reasons, including its sponsorship of an existing international working group dealing with the pre-detonation identification of nuclear materials[6.] Admittedly, on paper the CTBTO has the advantage of an established mission and an operational charter in some aspects of post-detonation nuclear forensics. It cannot perform many of these missions, however, until the Comprehensive Test Ban Treaty enters into force, which will not happen in the foreseeable future.[7]

In either case, the forensics team would be similar to the UN Special Commission inspectors in Iraq following the 1991 Persian Gulf War or the IAEA inspection teams that verified the dismantlement of the South African weapons program using weapons experts from a number of the nuclear-weapon states. In theory, they would have immediate access, *a posteriori*, to the debris and access, *a priori*, to nuclear weapon data. However, until the threat of nuclear terrorism is perceived far more starkly than it is today, the ideal case is not credible. Nuclear powers surround their databases with heavy secrecy and would be unlikely to share such data with an international team no matter what controls were placed on its members.

Nor is the secrecy unjustified. The United States and Russia know a great deal about nuclear weapons that could be of benefit to terrorists, particularly if the terrorists attempted to build a nuclear weapon from stolen material of unknown purity or from reactor-grade plutonium. The possibility that the weapons data provided to an international organization for an international forensics team might be leaked or otherwise compromised makes the sharing of data of this type unlikely. In short, the bridge is still too great to cross, and it will remain so until the threat of nuclear terrorism becomes much more feared than it is today.

Interim Steps

Nevertheless, smaller steps towards building a credible forensics team are possible and could proceed on two fronts. The first is to replace the international concept with a series of bilateral arrangements, beginning with one between the United States and Russia. The second is for each partner, individually and then jointly, to examine what data could be provided to a carefully chosen and controlled bilateral team. Much of the secrecy shrouding the nuclear arsenals of the two superpowers is based on the fears of the Cold War. Such secrecy may have been important then but not nearly so now in the face of the new nuclear age involving use of nuclear weapons by terrorists.

In this struggle, the two superpowers are close allies. Russia is deemed by many to be a likely source of fissile material. The United States, meanwhile, is judged to be a likely target, with Russia not too far behind. Such conditions can make allies of even the worst of antagonists. Furthermore, if the United States and Russia agreed to cooperate in this manner, it seems likely that the other recognized nuclear powers - France, the United Kingdom, and perhaps China - would follow. The threat of nuclear terrorism is, after all, international; the response should be the same.

For now, unfortunately, even a tightly controlled, Russian-U.S. bilateral forensics team may be a step too far. The experience of the CTR program, by which the United States assists Russia in dismantling many aspects of its nuclear arsenal, suggests that U.S. access to Russian nuclear weapon data will be extremely difficult to acquire. There are also many U.S. experts who would argue that the Washington should be no more forthcoming in providing its data to such a forensics team for similar reasons. Given the potential difficulties, an even smaller step is possible and should be considered.

Building on the Experience of Cooperative Threat Reduction

The CTR experience has demonstrated that progress has only been made after the legal aspects of an endeavor have been resolved to the satisfaction of each country. This suggests that there is a necessary first step that could be taken now. This would not involve exchange of data, but it would put in place all the agreements, including characterization of the data, required to implement a joint forensics team at any point in time, including immediately after a nuclear explosion in any Russian or U.S. city or even anywhere in the world. In short, both governments could agree on procedures, techniques, equipment, and even personnel that would be used should an attack occur.

The agreements could further ensure that the necessary arrangements are made for rapid transport of specialized technicians and equipment to the scene of the explosion to gather samples or other data. If a precisely defined team were formed, a three-fold advantage would ensue. First, a bilateral team whose capability was made known to all potential suppliers of contraband fissile material would have a deterrent effect as there would be a signature. The signature would admittedly not be as clear as that from a missile launch from an established country, but it would be a signature nonetheless. The deterrent effect would be further strengthened if there were a joint U.S.-Russian statement to the effect that the supplier would be held responsible.

Second, of all the successes the CTR has achieved during the past decade, one of the most profound and unanticipated has been the close working relationship between a long-standing and unchanging team of experts from the Department of Energy laboratories and the Russian navy. As with most human relationships, a bond of trust was formed over the years based on professionalism and sense of purpose. The same could be true of the suggested bilateral forensics team. Access to data is also likely to increase as the specter of nuclear terrorism continues to gain credibility. This would naturally cause suppliers to be less willing to arm terrorists.

Third, the unique nature and prestige of such a forensics team would hopefully impress more than suppliers. Political leaders and perhaps even the press would become aware of the existence of an authoritative source of accurate information on nuclear detonations. Public leaders would be more likely to forestall inflammatory pronouncements as the world waited the necessary time for accurate information from a unique and respected source, just as the United States did in the case of the potential bombing of TWA Flight 800[8]. Surely it would be to the benefit of all to wait a few days or a few weeks before taking extreme measures.

CONCLUSION

Although the arguments presented here have focused on the advantages and challenges of a U.S.–Russian nuclear forensics team in the face of an attack on Moscow, the symmetry of the situation is readily apparent. If an U.S. city were attacked, Washington would immediately seek to determine the origin of the weapon and its fissile material. The possibility of a Russian source would be high on the list, and there would be no better way to investigate this possibility than through the use of a highly credible bilateral team. Unlike most of the CTR programs, where the asymmetry between the U.S. and Russian situations has been apparent and sometimes painful, nuclear forensics in the age of nuclear terrorism could be truly symmetric. The United States and Russia would be clearly seen as equal partners embarked on a project of immense importance, not just to the two countries but to the entire international community.

Although it is conceivable that a U.S.–Russian forensics team could be formed, even that it could be extended to the established nuclear powers of the United Kingdom, France, and China, it is unlikely that other nuclear-weapons states or, more importantly, aspiring nuclear states such as Iran and North Korea would allow access to their nuclear data. Such states might even provide fissile material or weapons to terrorists.

Of what value, then, is multilateral forensics? First, there is the simple process of elimination: there is value in knowing where the weapon did not originate. Second, an urban nuclear detonation would be so horrendous that concerted and cooperative action by the established nuclear-weapons states with regard to finding the source might open the seemingly closed doors of any nation to its nuclear secrets. Finally, the ancient Chinese proverb seems to apply, "the longest journey begins with a single step."

All hope that the efforts to preclude a terrorist nuclear detonation are successful, but if such an event did occur, timely and credible data is needed on the likely source or sources of the fissile material or the nuclear device. A determination would help in restoring confidence to populations fearful of additional detonations and provide governments with evidence to pursue and find the perpetrators and eliminate further threats. The credibility of the nuclear forensic information would be significantly enhanced if provided or corroborated through a multinational or at least a bilateral nuclear forensic team. Such cooperative activities could be fostered by approaches similar to the joint U.S.–Russian CTR programs of the past decade.

SIDEBAR
POST-DETONATION NUCLEAR FORENSICS

As responsible governments want to locate nuclear weapons in the hands of terrorists before they are detonated, they have tended to focus on improving methods to detect fissile material (pre-detonation) more than using forensic techniques to determine the products generated by fission (post-detonation). Pre-detonation technology includes x-ray machines that may show the presence of a nuclear device and gamma-ray detectors that indicate the presence of fissile material. In post-detonation forensics, the arcane field of radio-chemistry plays a major role.

In the event of a nuclear explosion, radiochemists would seek to obtain minute quantities of debris from the nuclear device near ground zero and/or in the atmosphere. They would first separate the atoms into groups of chemically similar elements and then measure the radioactivity of each group. To do so, scientists often employ gamma-ray spectroscopy to measure the time of emission and the energy of each detectable gamma ray, electromagnetic radiation produced by radioactive decay.

The energy of the detected gamma ray is unique to each isotope of a specific element, thereby indicating its presence in the debris. Furthermore, the rate at which that isotope emits its signature gamma ray decays in time according to its unique half-life, thereby providing a second identifier of the isotope. By knowing the chemistry of elements that have been separated, the energy of the gamma rays of any radioactive atoms in that chemical group, and the rate at which the emission of the gamma-rays at each particular energy level decays over time, scientists can obtain an accurate measurement of many of the isotopes of the chemical elements in the debris. Because there is always experimental uncertainty, particularly with small samples, all three processes (separation, energy measurement, and time dependence) may be used.

Three types of atoms are of particular interest in a forensic analysis:

- *Atoms of fissile material that did not undergo fission.* Examing them allows scientists to identify the material used to make the device and, when compared to the number of fission fragments, to measure the efficiency or sophistication of the weapon.
- *New atoms created by fission and by other nuclear reactions within the fissile material*. When scientists compare these, they can obtain considerable insight into the nuclear processes that were involved during the actual explosion.
- *Atoms of material near the fissioning core that were subjected to an intense bombardment of neutrons during the explosion and became radioactive as a consequence*. These atoms provide insight into the components of the weapon and the energy of the neutrons that activated the components.

Post-detonation forensics are, by no means, limited to the steps noted above, nor does the description of even these steps do justice to the creativity and sophistication of instrumentation and techniques that have evolved since the beginning of the nuclear age and which continue to evolve and improve in the face of nuclear terrorism. The Departments of Defense, Homeland Security, and Energy have substantial and continuing research and operational programs in the field.

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[1] See John B. Dunlop, *The 2002 Dubrovka and 2004 Beslan Hostage Crises: A Critique of Russian Counter-Terrorism*, *ibidem*-Verlag: Stuttgart, 2004.

[2] See Mark Kramer, "The Sinking of the Kursk," PONARS Policy Memo #145, September 2000.

[3] Dr. Edward Walker of the University of California (Berkeley) contributed greatly to these concepts.

[4] TWA flight 800 exploded at low altitude during takeoff from Kennedy Airport on 17 July 1996. Initial suspicions were that it was attacked by a ground-to-air missile.

[5] The half-life is the time required for half of the atoms in any given quantity of a radioactive isotope to decay, emitting some form of nuclear radiation.

[6] Nuclear Forensics Support; IAEA Nuclear Security Series No. 2; International Atomic Energy Agency Vienna, 2006

[7] To monitor and verify compliance with the CTBT, a global network of monitoring stations is nearing completion and an International Data Center based in Vienna is operational. The monitoring network, which includes radionuclide monitoring stations, is already delivering data that is available for more detailed analysis by individual CTBT signatory states. Data derived from the radionuclide stations could

potentially provide information relevant for attributing the source of the material used in a nuclear detonation. The on-site inspection functions called for under the CTBT, however, will not be available for use until such time as the CTBT enters into force. Such inspections are primarily designed to determine whether a nuclear detonation has or has not taken place.

[8] Conclusive evidence that the explosion was caused by an internal malfunction rather than a ground-to-air missile was not available for many months, but the prestige of the National Transportation Safety Board was (and is) such that the U.S. decided to take no adverse action until the NTSB had made its determination. By then, of course, retribution was moot.

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