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EDITOR'S NOTE

Since 11 September 2001, the concept of nuclear terrorism no longer seems far-fetched. Scenarios such as a suicide attack on a nuclear power plant or a 'dirty bomb' detonated in an urban area have been played out in the media, by government officials and experts—sometimes in an alarmist fashion and often generating more questions than answers. Are dirty bombs nuclear weapons? Are terrorists capable of building a nuclear weapon? Could they buy one? There seems to be widespread uncertainty concerning the capabilities of terrorists and the threat posed by them. In this issue of *Disarmament Forum*, experts examine terrorist capabilities and means, distinguish hype from real concerns, and propose arms control responses.

Arms control can make vital contributions to reducing the opportunities for nuclear terrorism. Initiatives ranging from verification and transparency measures to new treaties could promote more secure materials and facilities, as well as increased confidence in that protection. Greater awareness of the possibility of terrorists developing or using nuclear weapons or radiological devices has resulted in renewed attention on activities to develop and strengthen countermeasures to protect nuclear weapons, materials and facilities.

The next issue of *Disarmament Forum* will consider the linkages between disarmament and development through the lens of a specific weapon: landmines. Landmines pose significant challenges to post-conflict reconstruction and economic development in numerous countries around the world. This issue will explore the synergistic relationship between disarmament and development, and contribute to our understanding of how these dual objectives can be implemented in tandem on the ground.

As part of its commitment to disarmament and non-proliferation education UNIDIR is sponsoring an exhibition entitled 'Linus Pauling and the Twentieth Century' at the Palais des Nations. Held to coincide with the NPT Preparatory Commission, the exhibition examines the life of one of the world's best-known scientists and peace activists. In his lifetime, Linus Pauling received both the Nobel Prize in chemistry (1954) for his work on chemical bonds and the Nobel Peace Prize (1962) for his courageous fight against nuclear-weapons testing. In the context of changing security perceptions throughout the world, Pauling's fight against the inhumanity of nuclear weapons has never been more relevant.

This remarkable exhibition explores some of the most significant issues of our time: nuclear weapons, science and peace. Created through cooperation among Pauling's family, Oregon State University and Soka Gakkai International (SGI), its Geneva sponsors are UNIDIR, the University of Geneva and CERN.

Following its role as consultant to the 2001–2002 United Nations Panel of Governmental Experts on Missiles, UNIDIR, jointly with the Institut français des relations internationales (IFRI), held the seminar 'What Prospects for Missile Controls?' in Paris on 20–21 March 2003. The meeting provided an opportunity for informal, off-the-record discussion of the challenges posed by the spread of missiles and the qualitative improvement of missile capabilities. For more information about the conference, see UNIDIR Focus on page 71.

UNIDIR, in cooperation with the governments of Japan and Australia, convened the meeting ‘Promoting Verification in Multilateral Arms Control Treaties’ on 28 March 2003 to examine the lessons learned from existing multilateral verification regimes and to explore how these lessons can be applied to the creation of a fissile materials treaty. The meeting, held at the Palais des Nations, was addressed by verification experts from international organizations, research institutes and government agencies with the aim of generating new ideas and identifying common ground among Conference on Disarmament delegations.

The Roundtable feature of UNIDIR’s website (www.unidir.org) offers you an opportunity to participate in the work of the Institute in two different ways. E-di@logue is an electronic discussion, allowing users from around the world to explore disarmament, security and arms control issues interactively. Recently, e-di@logue participants have been discussing the conflict in Iraq and its ramifications for arms control and disarmament. ‘For comment’ papers are draft research papers posted online to stimulate discussion and feedback. You are welcome to send your thoughts, comments and critiques by e-mail (the contact information is noted in the ‘for comment’ paper). Your input will help us further refine or broaden our work. Feel free to circulate ‘for comment’ papers on an informal basis, but as they are drafts, they are not for citation.

While you are on the site, don’t forget to sign up for UNIDIR Highlights. This feature will automatically send you a message to announce new UNIDIR publications, papers, meetings and conferences, as well as job opportunities.

Kerstin Vignard

SPECIAL COMMENT

Nuclear Terrorism and Nuclear Arms Control

Changed security environment

Old certainties have gone. The bipolar Cold War order has vanished. The international community today is faced with multifaceted and multidirectional risks. Apart from an increased potential of regional conflicts, the proliferation of weapons of mass destruction and terrorism are of particular concern. The heinous attacks of 11 September 2001 have increased the awareness of the danger of terrorists gaining access to weapons of mass destruction, radioactive material and their means of delivery. To meet these new challenges, solidarity and common responses on the basis of jointly defined norms are more relevant than ever before. There is no room for a 'deregulation' of security relations. Instead we need a broad alliance and a common resolve in the fight against terrorism. Multilateral instruments in the field of disarmament, arms control and non-proliferation provide indispensable normative elements and can by way of their effective implementation reduce the risk of proliferation to terrorists. In addition, multilateral instruments can help bolster a durable international coalition against terrorism. Finally, the inherent limitations of an approach that is restricted to deterrence, defence and denial are obvious. Today's terrorists can hardly be deterred. We cannot build impenetrable defences nor, in a globalized world where there is universal access to technology and where secondary proliferation is rife, can export controls be fully depended on.

The threat of nuclear terrorism

Conventional wisdom has it that the likelihood of terrorists exploding a nuclear device is remote. Still this risk cannot be discarded entirely. The design for building a crude nuclear device is publicly available. The main obstacle for terrorists is to get access to weapon-grade nuclear material. This should draw attention to the existing, large stockpiles of nuclear weapons and weapon-grade materials and the potential risk they pose. The sheer numbers are impressive: globally there are approximately 30,000 nuclear weapons and more than 3,000 tons of highly enriched uranium and separated plutonium, the key ingredients of nuclear weapons.

The most likely threat faced by the international community is that terrorists might build a radiological device—a 'dirty bomb'—that disperses radioactive materials by way of an ordinary explosive. These materials are widely used worldwide and are often not adequately controlled. Whilst the tangible effect of such a weapon could arguably be described as limited, its use could have significant disruptive effects by creating panic, chaos and social disruption and thereby serving the primary objectives of terrorists.

The role of nuclear arms control

The overall objective in the fight against nuclear terrorism is preventing non-state actors from gaining access to nuclear weapons, radioactive materials and their means of delivery. Looking at the international arms control agenda, this objective can be addressed in a number of ways. The most sweeping and most effective measure would be the *complete elimination of nuclear weapons*. However, the attainment of this goal, as called for in Article VI of the NPT, requires conscientious preparations and political will. It cannot be realized in one step. It cannot be achieved for example by simply concluding a nuclear weapons convention and agreeing on a fixed timetable for the abolition of nuclear weapons. Rather the necessary prerequisites for a nuclear-weapon-free world must be fulfilled. Of particular importance in this regard is determining a reliable inventory of all nuclear-weapon stocks and fissile material usable for military purposes, the assured non-availability of weapon-grade fissile material, effective verification measures, and an environment that ensures that the prohibition of nuclear weapons does not result in the outbreak of large-scale conventional wars or a revaluation of chemical and biological weapons. These considerations clearly point towards adopting an incremental approach towards nuclear disarmament as set forth in the thirteen practical steps for the systematic and progressive implementation of Article VI adopted by the 2000 NPT Review Conference. Progress in the implementation of the thirteen steps, which represent the performance benchmark for nuclear disarmament, contributes to diminishing the dangers of nuclear terrorism.

In addition, the following measures must be addressed.

- *Improving the security of and accounting for nuclear weapons and their essential components*. The IAEA is serving as a catalyst for these efforts by providing assistance to states and establishing recommendations for minimal levels of security.
- *Increasing the effectiveness of the NPT regime*. Again the IAEA has a key role to play in the implementation and strengthening of safeguards. The efforts undertaken under its auspices to extend the coverage of the Convention on the Physical Protection of Nuclear Material is of particular importance regarding the protection of such materials from theft.
- *Disarmament cooperation*. The G8 Global Partnership adopted at the G8 Summit Meeting in Kananaskis in 2002 has given a new impetus to the efforts to secure and eliminate nuclear weapons and weapon-grade material in the former Soviet Union. Under this programme US$ 20 billion is to be spent over ten years on cooperation projects aimed at addressing non-proliferation, disarmament, counter-terrorism and nuclear safety issues.
- *Universalizing the NPT*. India, Pakistan and Israel still remain outside the NPT. The international community should continue to call upon them to join the NPT as non-nuclear-weapons states and thus make this instrument truly universal.

The contribution of the Conference on Disarmament (CD)

The CD can make a significant contribution in diminishing the risks of nuclear terrorism. Two subjects currently on the CD agenda stand out in this regard: negotiations of a Fissile Material Cut-off Treaty (FMCT) and a radiological weapons convention.

A coherent and comprehensive approach to weapon-grade fissile materials is overdue. Addressing the key components of nuclear weapons is clearly the next logical step in the process of nuclear disarmament. Much groundwork—including an agreement on a negotiating mandate—has been laid for starting an FMCT without delay. The Shannon Mandate, on the basis of which the CD took a decision in 1998 to establish an ad hoc committee, remains relevant. As an FMCT should also be an effective measure to counter the risk of fissile material being acquired by terrorists, it seems only natural to revisit, as regards the scope of the treaty, the issue of stocks. However, in order to avoid complicating a task which is already complex, the issue of stocks might best be dealt with in a sequential manner. Another important topic is the question of verification. Against the backdrop of the terrorists threat it is of particular importance to devise an effective verification system, which must apply equally to all parties of an FMCT.

Radiological weapons were actively discussed in the CD until 1992. Work was discontinued for many reasons, not least because such weapons were not considered to be an option pursued by states. However, with the new awareness that a ‘dirty bomb’ could be used by terrorists, it is time to revisit the issue. Whilst not detracting from the indispensable work done in the framework of the IAEA, in particular on the safety and security of radioactive sources, a radiological weapons convention could create a new international norm that would not only provide a barrier against the acquisition of radiological weapons by any state but provide a benchmark for judging state behaviour in this regard. It could also help legitimize, revalue and give an impetus to international efforts aimed at providing for more effective protection and control of radioactive materials. It could establish a legal obligation to secure radioactive materials and, to that end, establish common standards of national implementation including, *inter alia*, a requirement to enact penal legislation relating to any prohibited activity undertaken anywhere on the territory of each state party or in any other place under the jurisdiction or control of that party. A radiological weapons convention could be an expression of the fact that the issue of protecting radioactive materials is not a national matter but a shared responsibility of the international community, which also entails an enhancement of international cooperation. In revisiting the issue the CD should particularly address the questions of definitions, scope and verification; the problems associated with them do not seem insurmountable.

In the face of the urgent need to reduce the risks of nuclear terrorism the stalemate in the CD is no longer tolerable. The linkages which are being maintained between different items on the CD’s agenda and which block the start of useful work must be removed. At a time when the international community faces severe new security threats, such linkages are even more difficult to understand. Living up to its mission and its responsibility the CD should establish an ad hoc committee on an FMCT without further delay and also start exploring in depth the issue of radiological weapons. The costs and risks of failing to act are far higher than the costs of effective action now.

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Nuclear terrorism: risk analysis after 11 September 2001

Annette Schaper[1]

The smoke over Manhattan did not quite reach the size of a mushroom cloud. Nevertheless, the number of casualties was of the order that would be caused by a minor nuclear explosion. The idea that terrorists have access to weapons of mass destruction is a nightmare that governments and international organizations take seriously.

The events of 11 September have finally made it clear that mass murder can be a terrorist's objective—but the extent to which they have the technical ability to accomplish this is another question. The 11 September terrorists aimed to maximize the death toll they inflicted. Future attacks will always be compared to this one, therefore the ambition of successive assassins might be to beat this death toll. Nuclear weapons are particularly suited to maximizing the number of casualties and are more attractive to terrorists than biological and chemical weapons.[2] A nuclear explosion might therefore be the next step in the escalation of terror.

The aim of this paper is to assess the possibilities terrorists have for nuclear terrorism and to illustrate potential threats. The paper does not cover suggestions of how to cope with this threat, as this is the topic of other contributions in this issue.

In the following, an assessment is made of whether terrorists are capable of building or procuring a nuclear explosive device. In this discussion, two different terms should be distinguished.[3] A *nuclear weapon*, as can be found in the arsenals of the nuclear-weapon states, has a complicated design that is the result of years of development and many tests. Such a weapon is optimized in many respects. For example, the mass of the nuclear material is minimized, the explosion energy is controlled precisely, several safety mechanisms are in place to prevent unintentional detonation and the weapons are resistant to heat, pressure and radioactive radiation. Above all, a nuclear weapon can be delivered to its target by a ballistic missile. In contrast, a terrorist group could, at best, produce a simple *nuclear explosive device* (not to be confused with a radiological weapon) that would only be capable of generating a nuclear explosion. Like the nuclear bombs dropped on Hiroshima and Nagasaki in 1945, it would have a simple design, would require a large amount of nuclear material and would have a large mass that could only be transported by ship, boat or lorry but not by a ballistic missile. Moreover, the creators of such a device could never be entirely sure that it would really explode.

The theoretical know-how

During the Second World War, thousands of scientists and ancillary staff contributed through the Manhattan Project to the creation of the first crude nuclear explosive devices. The American government

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recruited the best scientists and dedicated enormous logistical and financial resources to the effort. When asking whether terrorists today might be in a position to construct such a nuclear explosive device without comparable efforts, one important point should be kept in mind: the physicists of the Manhattan Project did not know if a nuclear explosion would be possible, and years were spent on basic research and essential inventions. They had to produce the nuclear material themselves. Furthermore, the operating procedures had to be developed and studied.

Today, not only are the principles of nuclear weapons identified, the fundamental theories are also published in detail and are, to some extent, available even on the Internet.[4] These sources of information vary in their reliability and detail, and might include errors. However, they are based on information that has been declassified and that can be used to reveal and understand the relevant physical facts.[5] Declassification is merely a consequence of the inevitable scientific progress that has been made since the beginning of the nuclear age. Since those beginnings, the subject nuclear physics has been established, many textbooks written, numerous nuclear plants designed and the functioning of nuclear weapons further researched.

The development of ignition technology

But there is still information that is secret, especially in relation to engineering. Many laborious steps separate the basic understanding of the operating principles and an actual technical blueprint. Terrorist organizations would have to acquire special abilities and techniques in order to build even a simple nuclear explosive device. These include, for example, the generation of shock waves with the aid of high explosives, the handling of fuel and radioactive material, electronics, radiochemistry, and the precision mechanics of metallic uranium or plutonium. Even these subjects are covered in detailed specialist publications that are available not only in libraries but also on the Internet. It is possible to study these publications and use them as a basis for acquiring the relevant capabilities. However, many crucial details are secret, especially those that are based on experimental measurements rather than theory. Development work would be necessary to figure these out.

Terrorist organizations would have to acquire special abilities and techniques in order to build even a simple nuclear explosive device.

In principle, there are two different ignition techniques. Using the *implosion method*, as was used for the Nagasaki bomb, a hollow sphere of plutonium or highly enriched uranium (HEU) is imploded to create a so-called *overcritical* mass. When a neutron enters this mass, a *chain reaction* is started that leads to a nuclear explosion. In the case of plutonium, such a starting neutron will practically always be present, as plutonium generates initial neutrons through the high rate of *spontaneous fission*. HEU has a lower rate of spontaneous fission and thus a lower *neutron background*. Therefore, in the case of HEU, neutrons will have to be added artificially at a precise moment in order to start the chain reaction. A comparatively high compression can be achieved using the implosion method, which means that large overcritical masses can be achieved with relatively small amounts of material. The production of a warhead with this method requires complete mastering of the technique of generating precise spherical shock waves. This in turn requires preliminary tests involving many conventional explosions that would probably take several years.

Using the *gun-type method*, two non-critical masses of HEU are shot at one another to generate an overcritical mass. It should be noted that only HEU is suitable for this method. The use of plutonium would lead to only a small detonation on the scale of a conventional explosion. Compression cannot be achieved using the gun-type method. Thus, several tens of kilograms are necessary and only a relatively small overcriticality can be achieved. Nevertheless, this method can be sufficient to generate a nuclear explosion on the scale of the Hiroshima bomb. This method was used by South Africa to build six warheads.

It is not sufficient to simply ‘drop’ one part of HEU onto another. Although HEU generates fewer spontaneous neutrons than plutonium, to avoid pre-ignition the two parts must be combined quickly (in a time that is shorter than the average time between the emission of two neutrons). To combine the two halves at the necessary speed, the terrorists would have to develop a technique to shoot the two parts at each other in a gun barrel. This presents an engineering challenge that is not trivial, considering the large masses involved, and which would presumably require months—if not years—of preliminary tests.

But it should be kept in mind that in the now-abandoned South African nuclear weapons programme, the development of the ignition technology was only a small part of the larger programme, and it required a relatively small amount of effort.[6] A fraction of this effort would probably be sufficient for terrorists, as they are more likely to be interested in a one-off, functional product rather than a long-term development programme.

In theory, it is possible for a highly motivated and financially well-endowed terror organization to acquire the technical abilities necessary to manufacture an ignition mechanism for a nuclear explosive device.

In theory, it is possible for a highly motivated and financially well-endowed terror organization to acquire the technical abilities necessary to manufacture an ignition mechanism for a nuclear explosive device. However, this would require enormous efforts. Various specialists would have to acquire the required theoretical knowledge and technical skills, perhaps requiring university studies abroad. Revelations over the preparations undertaken for the attacks against the World Trade Center show that terrorists are prepared to go this far to achieve their aims. The organization would need shelter for several years, where their work and the necessary experiments can be carried out undisturbed. Such a base could hardly be mobile, as a test site would be needed to undertake conventional explosions, together with some research labs and offices.

For the development of the ignition mechanism, it is not required to handle plutonium or HEU. Thus, hiding the base would be comparatively easy. Research into conventional explosives is usually realized in a military environment and, therefore, hardly accessible for outsiders, for obvious reasons. Nevertheless, the cover and protection by a state is required, as the existence of a base and the experiments carried out there would be noticed by nearby residents. Covert programmes would be much easier to undertake in a ‘failed state’ environment. If a state comes under suspicion, it will always face the risk of intelligence services discovering the base.

The procurement of nuclear material

Should a terrorist group master the ignition technique, then an operational weapon can be assembled quickly once enough plutonium or HEU comes their way.

The United States Department of Energy issued the warning in 1997 that:

> Several kilograms of plutonium, or several times that amount of HEU, is enough to make a bomb. With access to sufficient quantities of these materials, most nations and even some sub-national groups would be technically capable of producing a nuclear weapon… .[7]

It is far more difficult to get hold of the necessary nuclear fuel than to develop the ignition technology. Nuclear material exists in many different forms. Of these, only metallic plutonium or HEU can be used directly in nuclear weapons without requiring further processing. As a rough estimate, beginners would need at least 20kg of HEU or 10kg of plutonium in order to build one warhead using the implosion method. Using the gun-type method, an estimated 50kg of HEU is needed. A terrorist group would only choose to pursue the gun-type method if it was sure of having access to enough HEU.

Globally, there are about 250 tons of military plutonium and about 1,700 tons of military HEU. Civil stocks have to be added to this. Obviously, this and other nuclear material is subject to strict security measures. Additionally, nuclear material located in non-nuclear-weapon states is subject to controls ('safeguards') by the International Atomic Energy Agency (IAEA). Safeguards are designed to detect a theft as early as possible, leaving enough time for the international community to react before a terrorist nuclear device is operational.

The five nuclear-weapons states are not required by the Nuclear Non-Proliferation Treaty (NPT) to conclude IAEA safeguards agreements. Of the five, the security of nuclear material in the states of the former Soviet Union has been the subject of great concern for many years. It seems that an exact overview of stocks has been lost or never existed in a sufficiently accurate form. Moreover, many plants and storage facilities are not adequately secure today. It is not known whether terrorists or third party states have already managed to get hold of nuclear material. However, it is certain that many attempts have been made. Several cases were uncovered in the mid-1990s, where smugglers stole weapon-ready nuclear material, sometimes in kilogram amounts.[8] In 1998, the Russian government revealed that plans had been uncovered to steal 18.5kg of HEU from one of the nation's largest nuclear weapon plants. The plan was stopped before the material had left the plant.[9]

It is, however, possible that thefts have been executed on other occasions that have never been discovered. It is not known whether potential thieves of nuclear material, smugglers and recipients have already carried out successful transactions. Thus, it is possible that a terrorist cache of sufficient nuclear material to build a weapon already exists; it is impossible to know.

Thus, it is possible that a terrorist cache of sufficient nuclear material to build a weapon already exists; it is impossible to know.

The problem of insecure nuclear material is not confined to the former Soviet Union. Even in the United States complaints about the limited security surrounding weapon-ready material have repeatedly been filed, even though the security is much more strict than in the Russian Federation and more modern regulations concerning the physical protection of nuclear material are in place.[10] It should be noted that the United States, as a nuclear-weapon state, is not subject to mandatory international controls. In the first decades after the invention of nuclear weapons, the recording of nuclear materials was very incomplete. In 1996 the United States Department of Energy published a detailed account of the history of American plutonium production.[11] It was demonstrated that 2.8 tons of plutonium are 'missing', which means that the stocks taken by measurement and the number calculated from historical documents differ by 2.8 tons. This material has not necessarily been lost or stolen—the discrepancy could just indicate the extent to which the early recording of material was inexact. However, what becomes clear is that it is not possible to determine whether material has been taken away in the past. It can be assumed that such inaccuracies are even worse in the Russian Federation.

Metallic plutonium is difficult to process, due to its radiotoxic properties and its reactivity. A terrorist group would be unlikely to have practical experience in processing plutonium, and therefore would be taking on substantial health risks and risks of accident. However, it is assumed that they are willing to put up with these risks. The handling of metallic uranium is slightly easier.

It can be ruled out that a terrorist group has the capability to produce plutonium or HEU. At most, only a state with appropriate resources could carry out such an endeavour, and it is doubtful whether such a programme could be kept hidden for long. Large-scale nuclear plants are necessary, the procurement and operation of which could not be kept secret. All procedures for the enrichment of uranium or for plutonium reprocessing leave traces in the environment. In case of a suspicion in non-nuclear-weapon states, illicit activities could be discovered immediately as all plants are subject to IAEA safeguards. The production of uranium or plutonium is extraordinarily resource intensive, as can be illustrated by the fact that Iraq employed thousands of members of staff throughout the 1980s in order to clandestinely manufacture HEU. Nevertheless, only small amounts of HEU were produced. At that time, the IAEA inspections were less thorough and the extent of the production activities was only discovered after the Gulf War. As a result of this deception, IAEA safeguards have been strengthened and it is considered improbable that a similar case could go undiscovered today.

A second consequence of discovering the Iraqi programme is that the industrial states now cooperate through their intelligence services, the agencies responsible for export licenses, and through control regimes to observe international procurement activities. Moreover, other pieces of information, for example from intelligence or from satellite images of individual states, may be provided to the IAEA for evaluation. The technique of collecting and collating scattered pieces of information and their interpretation has improved immensely. The IAEA maintains a database in which such information is centralized. Therefore, the IAEA is capable of drawing attention to suspicious facts at a very early stage.[12] Routine IAEA inspections can be complemented with special inspections where appropriate.

The civil nuclear activities of most countries are transparent. There are, however, a small number of exceptions. Iraq is amongst these, as the IAEA has not been present in Iraq since 1998. The enrichment plants that existed before the Gulf War have been rendered useless and all nuclear material found has been removed from Iraq. As international technical cooperation with Iraq no longer exists, thorough observations are carried out by satellite. However, the technical know-how is still present, presumably including knowledge about ignition technology. Without controls, a small but significant risk remains that Iraq may obtain enough HEU for a nuclear explosive device and could decide to cooperate with or sponsor a terrorist group. At the time of writing (March 2003) UNMOVIC inspectors had not found any traces of HEU production attempts after 1998.

Without controls, a small but significant risk remains that Iraq may obtain enough HEU for a nuclear explosive device and could decide to cooperate with or sponsor a terrorist group.

A further exception is North Korea, which has attempted to produce plutonium in the past. These activities were detected by the IAEA. However, North Korea is not in compliance with its IAEA obligations, and the IAEA is not able to reconstruct North Korean past production. It cannot be ruled out that North Korea is in possession of plutonium sufficient for several warheads. However, it is extremely unlikely that Pyongyang would cooperate with terrorists or that terrorists could get access to this material.

Before South Africa signed the NPT in 1991 and submitted itself to IAEA safeguards, it had produced large amounts of plutonium in its secret nuclear weapons programme. Since then, these stocks have been completely accounted for.[13] Today, an undiscovered theft is just as unlikely as in the other non-nuclear-weapon states. However, some amounts might have been covertly sold in the past, and they might be in the possession of criminals today. It has been reported, for example, that Osama bin Laden attempted to procure HEU of South African origin in 1993/1994.[14] It is unknown whether he was successful.

In addition, for years the United States has openly voiced its suspicions that Iran is interested in secretly developing a nuclear weapon capability. The American suspicion is said to be based on the testimonies of unnamed arms dealers, which refer to Iranian representatives allegedly enquiring about the possibility of purchasing fissile material. It is also based on alleged attempts by Iranian officials to buy enriched uranium in Kazakhstan and on the purchase of dual-use goods that might indicate an interest in the centrifuge enrichment technique. This has been supported by intelligence agencies in other countries. It has been reported that the German Federal Export Office has prohibited any delivery to Sharaf University in Tehran since 1996, after this university had attempted to purchase pieces of equipment for the manufacture of centrifuges. Another source of suspicion is Iran's recently revealed start of construction of a uranium enrichment plant.[15] However, Iranian non-compliance with its NPT commitments has never been proven. Recently, the IAEA requested to inspect certain sites in Iran and, after some delay, the Director-General and technical experts were invited to visit and inspect the facilities. The issue of evidence and demonstration of compliance is likely to be contentious for some time to come. There are competing political factions in Iran, some of them interested in strengthening the non-proliferation regime and preventing the development of nuclear weapons or the support of nuclear terrorism, others aiming at the contrary.

The case of Pakistan merits particular attention. It has a small arsenal of nuclear weapons and has produced larger amounts of HEU. Its nuclear capacity is sometimes polemically referred to as the 'Islamic bomb'. However, Pakistan's nuclear weapons programme was initially independent of religious motives or fundamentalism. Rather, it was initiated by the complex relationship with India. Pakistan has repeatedly stressed that it would not pass on any of its nuclear weapons and that it would not cooperate with other states in this field.

Little is known, however, about Pakistani national security measures. Parts of the population sympathize with the Taliban and radical terrorists. It is unknown whether religious fanatics could get access to nuclear material and could pass it on to terrorists. Two retired nuclear physicists who participated in the construction of Pakistan's nuclear weapons were arrested at the end of October 2001.[16] They are Taliban sympathizers, who had recent close contact with the former government of Afghanistan. It is not clear whether they passed on nuclear material. They were released after a few days, although the case will be investigated further.

Whether the Pakistani government is capable of preventing theft of nuclear materials remains unknown. In Pakistan, the army has always had control over the nuclear activities, and the various civilian governments were only marginally involved.[17] The October 1999 coup eliminated the last remaining civilian influence. The army may sympathize with the Taliban in the same way as the civilian population and this support might increase, depending on how the military operation in Afghanistan develops. There are reports claiming that Pakistani officers helped protect the Taliban from American air strikes, which would be strictly against the orders of their President, General Pervez Musharraf.[18]

At present, Pakistan possesses 585–800kg of HEU and several kilograms of plutonium. This amount would be enough for an estimated thirty to fifty warheads.[19] The Pakistani government assures that it is in full control of this nuclear material and of its nuclear weapons. However, there are indications that Pakistani physical protection is inadequate. Over a year ago, Pakistan asked the United States for assistance to improve the physical protection of all nuclear material.[20] The parts containing nuclear material and the ignition mechanisms of Pakistani nuclear weapons are apparently stored in different locations.[21] However, they are not protected against accidental detonation nor equipped with 'Permissive Action Links'—protective devices preventing unauthorized ignition. If terrorists were to get hold of a Pakistani nuclear weapon, then they would be able to detonate it. The locations of Pakistani nuclear sites are kept secret, in contrast to those of the recognized nuclear-weapon states, which are easily identified because of their high degree of physical protection. The reason for this secrecy is that the physical protection in place would be unable to withstand a significant attack. Immediately after the 11 September attacks, the nuclear-weapon components were transferred to other secret locations in Pakistan. The Pakistani government feared that the storage sites could be terrorist targets. These transfers also served the purpose of removing control over the nuclear weapons from religious hardliners inside the military.[22]

Radiological weapons and sabotage

A variant of nuclear terrorism that is technically much less challenging would be the use of a *radiological weapon* (a 'dirty bomb') instead of a nuclear explosive device. Such a weapon is detonated by a conventional explosion and distributes highly radioactive material. Several blocks of a city could thus be made inhabitable for many years. Plutonium and HEU, which are used in nuclear weapons, are not only difficult to obtain but are also not very radioactive. Therefore, they are not suitable for a radiological weapon.

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Spent fuel elements are more radioactive than plutonium and HEU and are produced by all civil nuclear power stations. However, theft of spent fuel elements is extremely difficult; because of their high radioactivity they would quickly release a lethal dose of radiation if not adequately shielded. Moreover, they are very heavy and bulky. The theft of such elements would require the use of an appropriate form of transport.[23] In Germany, spent fuel is transported by rail in specially designed, shielded containers. It is very difficult but not entirely impossible to imagine terrorists organizing a raid to capture and remove such containers. In non-nuclear-weapon states, all spent fuel elements are registered by the IAEA and a theft would almost certainly be quickly discovered.

A terrorist would find it much easier to get hold of high-level radioactive waste emanating from reprocessing plants, or special radioactive materials and solutions used in civil research institutes and hospitals. Reprocessing plants in non-nuclear or Euratom states[24] are, however, tightly controlled. Moreover, detectors that can register even small doses of radioactivity are placed at all entrances and exits and at other locations. Nevertheless, there is no way of ruling out the possibility of groups of staff conspiring to illegally remove small amounts of liquid high-level waste. A more plausible scenario is the theft of material from those less secure plants that are not subject to international controls.[25] Liquid high-level waste could be added to drinking water, so contaminating the entire area supplied by a particular source. It might also be discussed whether powerful terrorists could manage to capture a ship transporting radioactive material. However, since such transports are heavily guarded, a terrorist group would have to be extremely powerful and highly organized, comparable to the military forces of a state. Moreover, due to the efforts and risks involved, it would be more likely that such terrorists would aim to capture separated plutonium for a nuclear explosive device, rather than radioactive waste for a radiological weapon.

A more probable scenario is an attempt by terrorists to acquire special highly radioactive sources as are used for medical, industrial, agricultural and research applications. The materials that pose the greatest security risk are Co-60 (cobalt), Cs-137 (cesium), Ir-192 (iridium), Sr-90 (strontium), Pu-238 (plutonium), Am-241 (americium) and Cf-252 (californium).[26] They are produced primarily in nuclear reactors. Even gram quantities contain more than enough radioactivity to raise a security concern. Depending on their application, these sources come in various forms, quantities and shieldings. Some of them are not very mobile, others are so radioactive that they would cause immediate harm to an unprotected thief. Nevertheless, these materials can be found in a large number of research laboratories, industries and hospitals all over the world. Their protection is generally mediocre, and thieves might be able to steal these types of sources. No reliable inventories of these materials exist, and a large percentage of them are no longer in use, have been discarded or are lost. Although the number of abandoned or not well-protected sources is high, only a small percentage of them pose a serious security risk—but they are the ones that might be used for a radiological weapon. In the United States, as many as 375 radioactive sources were reported lost, stolen or abandoned in a single year.[27] Similar numbers can be assumed in many other industrialized states. Specific details about these sources are scarce because they are regarded as commercial secrets.

A serious concern are sources that are strewn throughout the former Soviet Union, most of them left behind by the Russian army during its return to the Russian Federation. In the 1970s, Soviet scientists working with the military developed scores of radioactive sources and dispatched them to the countryside in order to deliberately expose plants to radiation and measure the effects.[28] All of the experiments used Cs-137 in a shielded canister containing enough radioactivity to contaminate a small city. The material is highly dispersible—ideal for terrorists who seek to construct a radiological weapon. Meanwhile, international nuclear experts have searched for the devices, and found some in Georgia and Moldavia. But there is no accountancy, it is unclear how many are still out there and whether terrorists are searching too. Radioactive sources have turned up repeatedly on the black market. They are also known to have been acquired by Chechen rebels in the Russian Federation.[29]

Depending on where it was detonated, a radiological weapon would initially cause few casualties and cannot be regarded as a weapon of mass destruction.

Depending on where it was detonated, a radiological weapon would initially cause few casualties and cannot be regarded as a weapon of mass destruction. Nevertheless, the psychological impact and its social and economic consequences would be enormous and the contamination would have dreadful long-term consequences. Radiological weapons have never been used. However, it is thought that in 1980 Iraq produced and tested conventional bombs filled with radioactive material, presumably from spent fuel elements.[30]

In a computer simulation of a dirty bomb attack on New York City, the detonation of 3,500 curies of cesium chloride in Lower Manhattan would spread radioactive fallout over sixty city blocks. Immediate casualties would be limited to victims of the immediate blast. The after effects, including relocation and cleanup, would cost tens of billions of dollars.[31]

Nuclear plants have frequently been the focus of terrorist and criminal interest. Attempts at invading, attacking or threatening nuclear power stations have been reported in Argentina, the Russian Federation, Lithuania, South Africa, South Korea and even in the United States and France.[32] Not all such attempts are classified as large-scale acts of terror, as some of them are ‘only’ sabotage attempts by discontented staff or bomb scares in nuclear power stations. There have, however, been cases of threatened suicide attacks by plane hijackers, for example in November 1972, when three hijackers threatened to bring a plane down on a nuclear research plant in Oak Ridge.[33] Another widely discussed scenario involves a passenger plane, with full fuel tanks, being crashed into a nuclear power station.[34]

The containment design of German nuclear power stations takes into account the possibility of a combat aircraft crashing but not of a plane with full fuel tanks. An IAEA spokesperson recently confirmed that this also applies to other countries’ designs.[35] The containment would probably not withstand such an attack. The core of the reactor is unlikely to be hit but the cooling system might be destroyed. If the emergency cooling system, which is designed to flood the reactor in such a situation, were to fail, it could lead to overheating of the core and a Chernobyl-type catastrophe. Whole regions would be rendered uninhabitable. However, to succeed in releasing the radioactive contents of a nuclear power station, terrorists would have to be capable of hitting the reactor shield vertically—in a nosedive—rather than just scraping it from the side. This is a far greater challenge than directing a plane into a high building and is very unlikely.

A more likely scenario is sabotage of a nuclear plant with the aid of insiders. The Chernobyl accident was caused by fatal errors of the personnel during an experiment. Similar actions might be conducted deliberately by malevolent staff, either for non-political reasons (such as psychological problems), or by political motivation and collaboration with terrorists.

Conclusion

In sum, the threat that terrorists might detonate a nuclear device or conventional explosive to disperse radioactivity is real. It is unknown whether concrete preparations to do so are already underway. In addition to the current anti-terrorist armoury, strategies must be implemented that would, in the long term, reduce this risk. These strategies include international cooperation to improve the security of nuclear materials as well as legally binding commitments that have the effect of increased shared international security standards, collaboration and transparency. These approaches will be further elaborated in the following contributions.

Notes

1 This article is based on parts of a translation of Alexander Kelle and Annette Schaper, 2001, *Bio- und Nuklearterrorismus – Eine kritische Analyse der Risiken nach dem 11 September 2001*, HSFK-Report, 10/2001, Frankfurt, December. An English translation is forthcoming.

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3 Tom Shea, 2001, *Proliferation, proliferation resistance and proliferation barriers*, presentation at the Workshop on Innovative Directions for the Future Development of IAEA Safeguards Technology, Landau Network – Centro Volta, Como, Italy, 2–6 July.

4 An example is Carey Sublette, 2001, Nuclear Weapons Frequently Asked Questions, 9 August (version 2.25), available at <http://www.fas.org/nuke/hew/Nwfaq/Nfaq0.html>.

5 An example of such a document containing declassified information is United States Department of Energy, Office of Declassification, Restricted Data Declassification Policy 1946 to the Present (RDD-6), 1 January 2000 <http://www.osti.gov/opennet/rdd-6.pdf>. The following publication is amongst the first concerning the function of nuclear weapons to be declassified: Robert Serber, 1982, *The Los Alamos Primer—The First Lectures on How To Build an Atomic Bomb*, Berkeley (written in 1943, declassified in 1965).

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24 Euratom monitors the civil nuclear power stations of two nuclear-weapon states, the United Kingdom and France.
25 States that are not subject to international controls of their plants are the United States, the Russian Federation, China, India, Pakistan and Israel. The levels of physical protection in these states differ to a great extent.
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The contribution of arms control to fighting nuclear terrorism

Li Bin and Liu Zhiwei

Since 11 September 2001, the world has developed a heightened awareness of the security threat posed by terrorists. Scenarios of terrorists using nuclear weapons or radiological devices have been widely discussed by media pundits, researchers, heads of state, specialists and generalists alike.

The global fight against terrorism requires efforts in many areas, from strengthened border controls to better coordination among numerous government agencies at the local, national, regional and international levels. As the international community attempts to come to terms with the threat of terrorism, it should build upon already existing foundations as well as develop new responses. Despite the fact that arms control predominantly involves commitments between states—not non-state actors—it can make a necessary and useful contribution to preventing terrorists from acquiring the capability to launch nuclear and radiological attacks (and in some cases has already done so).

Arms control is based upon cooperative approaches taken by national governments to strengthen national security, to protect civilians, or to allocate resources to other objectives, such as social development rather than military build-up. Following the end of the Cold War, global arms control efforts were very successful and a series of arms control agreements, such as the Comprehensive Test-Ban Treaty and the Chemical Weapons Convention, were concluded or reinforced around that time. However, in recent years arms control has been frustrated due to a multitude of reasons—from the rise of unilateralism to a false sense of security emerging after the end of the Cold War. Nowhere is this inactivity more evident than in the stalemate in the Conference on Disarmament. Today, the new common enemy—terrorism—could stimulate innovative arms control initiatives and lead to more cooperation rather than unilateralism in arms control and disarmament.

There is a synergistic relationship between arms control and anti-terrorism initiatives. Because arms control tends to constrain the possession, transfer or use of weapons and their components, it is certainly helpful in blocking terrorist access to these weapons. The cooperative nature of arms control can also encourage better coordination and confidence among national governments. A wide range of intergovernmental, national and non-governmental arms control fora exist that could be used to address the issue of nuclear terrorism. At the international level, the Conference on Disarmament and the United Nations Security Council should be at the lead. Although not specifically designed for this purpose, some agreements and organizations dedicated to the control of nuclear weapons, their components and radioactive materials, such as the Nuclear Non-Proliferation Treaty (NPT) and the International Atomic Energy Agency (IAEA), also make important contributions to reducing the terrorist threat.

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Nuclear terrorism

If terrorists were to acquire nuclear or radiological weapons, it would be a catastrophic event. A terrorist group would be much less cautious than a national government in launching a nuclear attack. Unlike governments, terrorists do not have to worry about protecting their citizens or national territory from a retaliatory attack. Even the mere threat of use of these weapons by terrorists could cause panic and social chaos.

We can imagine three kinds of nuclear terrorism. The first is to *disperse radioactive materials* (a radiological weapon or 'dirty bomb'). The second is to intentionally cause the leakage of radioactive materials by *attacking nuclear facilities*. These threats are also known as radiological attacks or nuclear blackmail.[1] Studies undertaken concerning the risk and potential for such attacks have been widely publicized and for the most part agree that efforts are needed to strengthen the safety and control of radioactive materials, waste and facilities.[2] The third option for terrorists would be to *explode a nuclear weapon*.

This article will focus specifically on how arms control approaches can help prevent terrorist action involving nuclear weapons and their components (such as weapon-grade fissile materials). Other articles in this issue address radioactive materials and nuclear facilities.

The risk of already existing fissile materials—and even nuclear devices—falling into the hands of terrorists is real and must be addressed.

It is important that all nuclear-weapon states and emerging nuclear-weapon states maintain and strengthen their capabilities to protect their nuclear weapons and materials, and convey a sense of confidence in such measures. In general, this requires three responses. First, there must be a robust protection system against loss of existing nuclear devices. Second, a quick and regular accounting system must be used to detect any loss in real time. Third, the capability to prevent unauthorized detonation should be included in all weapon designs. At present, however, national standards and practices vary considerably in these regards.

Obviously, meeting these requirements would be easier if there were fewer nuclear weapons, fewer deployment and stockpile sites, less frequent shipments and exercises with live weapons, and a lower state of readiness. The greater the number of existing weapons and the more widely they are deployed makes protection difficult and slows accounting. There are also significant concerns about 'loose nukes'. Small, easily transported nuclear weapons are technically feasible. Fears that terrorists might acquire 'suitcase bombs' from the Russian nuclear arsenal—or already have done so—continue to worry specialists.[3] Frequent shipments and exercises increase the chance of loss to terrorists. Fully assembled and on-alert weapons prepared for launch make unauthorized use of the weapons easier.

It is almost impossible for a terrorist group to produce fissile materials by itself.

It is almost impossible for a terrorist group to produce fissile materials by itself. The infrastructure for the production of fissile materials is hard to disguise and could be detected, for example through analysis of satellite imagery.[4] Building a production facility would be lengthy process, which would also increase the chance of detection. Therefore, the first step for a terrorist group wanting to build a nuclear device would most likely be to acquire a significant amount of fissile material.[5]

Very large inventories of fissile materials exist around the world—enough to produce tens of thousands of nuclear devices. Attempts at stealing fissile material have already been discovered.[6] To thwart future diversion attempts, solutions similar to those outlined for nuclear weapons need to be applied to weapon-grade fissile materials: a robust protection system against loss and a quick and accurate accounting capability to detect loss of a significant amount of fissile material. Reducing the overall amount of fissile material and the number of stockpile sites would also simplify its protection and accounting systems.

Some current arms control processes and initiatives are aimed at reducing nuclear arsenals, the frequency of exercises or manoeuvres with live weapons, and fissile material stockpiles. The following sections discuss four specific arms control efforts that could be useful to fighting nuclear terrorism: reducing both tactical and strategic nuclear weapons, negotiating a Fissile Material Cut-off Treaty (FMCT), and strengthening the non-proliferation regime and export controls.

Reducing TNWs

Tactical nuclear weapons (TNWs) are short-range weapons designed for use on the battlefield. Reducing the number of TNWs is an important arms control objective to prevent accidental or intentional nuclear war.

From the perspective of confronting nuclear terrorism, the existence of TNWs poses a significant problem. TNWs are at greater risk than strategic weapons to be lost or detonated because of their widespread deployment and high state of readiness. TNWs have been deployed around the world, even in areas affected by terrorist activities.[7]

In 1991 the United States and the Soviet Union announced unilateral reductions in their TNWs, feeling that the use of nuclear weapons on the battlefield is not realistic. Most American and Russian TNWs have been withdrawn from deployment. However, some TNWs remain deployed[8] and the United States is interested in developing new TNWs or modifying existing ones to attack deeply buried targets.[9]

Most state-built nuclear weapons are believed to have locks, such as a Permissive Action Link (PAL).[10] The objective of the lock is foil an attempt at unauthorized detonation; some locks go as far as disabling the warhead if too many false attempts are made. In the worst-case scenario, locks help to 'buy time' to recover the warhead. The case for TNW reductions is strengthened by the fact that it is not clear if all TNWs, especially those developed for quick use on battlefields, have this type of security feature. If not, a TNW might be ‘ready to use’ and therefore an attractive terrorist objective.

Existing arms control arrangements concerning TNWs are informal and are not legally binding. There is therefore little confidence in the thoroughness and irreversibility of tactical nuclear reductions. Fighting terrorism is an additional and pressing incentive for the United States and the Russian Federation to continue their tactical nuclear reductions. A first step would be to make their 1991 unilateral declarations legally binding; other nuclear-weapon states should be encouraged to enact similar agreements. In the longer term, to prevent a terrorist nuclear attack, nuclear-weapon states could formally commit to reducing TNWs to zero, which would include complete withdrawal and dismantlement of all existing TNWs, no development of new TNWs, and transparency arrangements to build confidence.

Fighting terrorism is an additional and pressing incentive for the United States and the Russian Federation to continue their tactical nuclear reductions.

Strategic nuclear weapons: deeper reductions and de-alerting

Thousands of strategic nuclear weapons are still deployed or stockpiled around the world. The 2002 Moscow Treaty signed by Presidents Putin and Bush offers little of substance on actual reductions, for example by not requiring that warheads taken out of operational deployment are dismantled. More disturbingly, the treaty lacks any verification or inspection provisions. Although strategic nuclear weapons are more strictly controlled than TNWs, the risk of loss still exists, especially during shipment and exercises with live weapons.[11] While statistically rare occurrences, accidents have happened and might permit terrorists to obtain nuclear weapons or their components.

Arms control approaches could make valuable contributions to preventing terrorist attacks involving strategic nuclear weapons. Deep reductions are an obvious step, including the withdrawal of most strategic nuclear weapons from deployment, the dismantlement of those nuclear warheads reduced, and verification and transparency arrangements. Similar to the case of TNWs, reductions will make the protection of the remaining strategic nuclear weapons easier and the accounting quicker. Besides the Moscow Treaty, no other strategic reductions are currently being discussed.

Nuclear de-alerting[12] is usually considered as a way to reduce nuclear tension or suspicion among countries and to prevent accidental nuclear war. De-alerting is also a way to reduce the chances of nuclear weapons being obtained and used by terrorists. This could be achieved by reducing the frequency of exercises with live strategic nuclear weapons; reducing the number of strategic nuclear weapons on mobile launchers and the frequency of their movement; deploying nuclear components separately, for example, tritium and rest of the warhead. Additionally this approach will significantly reduce the probability of accidents that could cause nuclear weapon loss and will make the unauthorized detonation of these weapons more difficult.

De-alerting is also a way to reduce the chances of nuclear weapons being obtained and used by terrorists.

Strengthening fissile material control

According to the IAEA, 25kg of weapon-grade uranium is defined as a ‘significant amount’, while only 8kg of weapon-grade plutonium is considered a ‘significant amount’. If the IAEA were to find a discrepancy equal to or greater than these amounts during fissile material accounting in a non-nuclear weapon state, the authority responsible for the materials would be immediately notified and requested to respond.

It should be noted that all nuclear-weapon states have uncertainties in the accounting of their total fissile materials that are much greater than the aforementioned amounts. These uncertainties accumulated over time as large amounts of fissile materials have been produced. Today this lack of precise baseline data makes the detection of material loss difficult. The more fissile materials are produced, transformed and transported, the greater these uncertainties will be. Maintaining large stocks of fissile material makes their protection problematic because they are spread among many different sites and are in different forms.

To make the protection of fissile materials more reliable and the accounting quicker and more accurate, it is necessary to dispose of excess fissile materials and therefore reduce the total amount and the number of deposit sites. Transparency arrangements concerning fissile material disposal might encourage confidence in safeguards and reduce the fear of diversion. To support fissile material reductions, the negotiation of a FMCT[13] as a universal and formal commitment not to increase fissile material stocks, would be the most obvious step—if the Conference on Disarmament could surmount its impasse. Until then, at a minimum, the nuclear-weapon states should maintain their *de facto* moratoria on fissile material production.

Strengthening the non-proliferation regime and export controls

The NPT was originally negotiated to address the concern over the transfer of nuclear technology and hardware between countries. In practice, the NPT (together with IAEA safeguards) has played an important role in preventing nuclear terrorism in different ways. First, the NPT formally prohibits all but five nations from developing nuclear weapons, which has helped to control the number of permitted nuclear-weapon states. Second, the NPT's strong restrictions over the transfer of nuclear weapon technology and components also pose a barrier for terrorists to acquire nuclear weapons. Third, IAEA safeguards help many countries to establish fissile material accounting and protection systems that deny terrorists access to nuclear technology and materials from civilian industry.

IAEA safeguards help many countries to establish fissile material accounting and protection systems that deny terrorists access to nuclear technology and materials from civilian industry.

In addition to near-universal agreements and institutions like the NPT and the IAEA, there are cooperative regimes—such as the Nuclear Suppliers Group and the Zangger Committee—that regularize the transfer of dual-use technologies. As most export control regulations and regimes require the suppliers to identify both the end use and end users of their dual-use products, these regulations can significantly reduce the chances of terrorists acquiring nuclear technology and components through international trade. Although control regimes can slow the proliferation of potentially dangerous technology, they are open to criticism as they are not universal and are considered by some non-members to be discriminatory.

National controls are also important. For example, before it promulgated its first nuclear export control law on 1 August 1997, China took an administrative approach to manage exports in this area by monopolizing international trade. As China moved towards a market economy over the last twenty years, it began to take legal approaches to regularize export in this area. Now China has a series of laws for nuclear and related technology export control. These laws are similar to those in other countries and they help China to coordinate with other countries in managing export control.

Although the existing non-proliferation regimes and regulations have played important roles in preventing nuclear terrorism, more efforts are necessary. First, most export control regimes and regulations were designed to prevent nuclear proliferation among countries and therefore they focus on monitoring international trade. As these laws cannot prevent terrorists from buying dual-use technology in domestic markets, domestic legislation should be enacted or strengthened.

Second, the situation of IAEA safeguards in threshold nuclear-weapon states is not completely satisfactory. As there is very little transparency in the nuclear programmes of these countries, there is insufficient confidence in the IAEA being able to detect discrepancies. It is therefore important that as many countries as possible adopt the enhanced safeguards of the IAEA.

For example, since joining the NPT in 1985, North Korea has never fully accepted full IAEA safeguards, claiming that American nuclear deployment in South Korea was an obstacle. The unilateral declaration of President Bush in 1991 to withdraw all TNWs abroad provided the first chance for North Korea to consider IAEA safeguard positively. The 1994 Agreed Framework between North Korea and the United States played a role in dealing with the tense situation of 1993. After eight years of recurring disputes about the implementation of the Agreed Framework, the issue of North Korea's nuclear programme has once again become urgent. As North Korea has expelled IAEA personnel, claims to have withdrawn from the NPT, and has restarted its nuclear reactors, there are increasing concerns about a weapons programme, the possibility of the government selling its nuclear technology, and lack of adequate controls to prevent theft or loss.[14]

It is necessary to persuade North Korea to come back to the NPT and adopt full-scope IAEA safeguards. It seems that North Korea wants a formal security assurance from the United States as a precondition to return to the NPT. If the United States makes a negative security assurance to North Korea to exclude both nuclear and conventional attacks against it, it might help to persuade North Korea return to the NPT.

Conclusion

As outlined here, arms control contributes to fighting terrorism by strengthening the safety and security of nuclear weapon installations, institutions and mechanisms. It should not be forgotten that arms control also builds social norms and taboos about weapon use. For example, a treaty banning radiological weapons or military action against nuclear facilities would not be able to directly prohibit terrorists from launching radiological attacks—as they are agreements with states, not non-state actors—but they could arouse social conscience and reduce the support of terrorists if they plan these sorts of attacks.

Notes

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Commercial radioactive sources: surveying the security risks

Charles D. FERGUSON, Tahseen KAZI and Judith PERERA

In June 2002, the Center for Nonproliferation Studies (CNS) of the Monterey Institute of International Studies launched a project, co-directed by Dr. William C. Potter and Dr. Charles D. Ferguson, to conduct a systematic assessment of all four major threats of nuclear and radiological terrorism. These threats are construction and use of radiological dispersal devices or 'dirty bombs', theft or purchase of fissile material in order to build improvised nuclear devices, acquisition of intact nuclear weapons, and attacks or sabotage of nuclear power installations or other nuclear facilities. Although many governments have renewed efforts to combat nuclear and radiological terrorism soon after 11 September 2001, they are still in need of a careful and systematic assessment of these threats in order to determine how to effectively direct limited resources. The CNS nuclear and radiological terrorism assessment project endeavours to provide this guidance to government officials and other policy makers. As the first part of this project, CNS examined the radiological dispersal device threat.

This study examines the security risks posed by commercial radioactive sources. While these sources provide benefits to humanity through numerous applications in medicine, industry and research, some of these same materials, if not secured, may end up in radiological dispersal devices (RDDs)—one type of which is popularly known as a 'dirty bomb'. Though RDD use has not occurred, the 11 September 2001 terrorist attacks, al-Qaeda's expressed interest in acquiring the means to unleash radiological terror, and widespread news reporting on this topic have sparked renewed concern about the security of commercial radioactive sources.

Although radioactive materials other than commercial radioactive sources—such as radioactive waste from nuclear power plant operations—might contribute to the components of an RDD, an examination of these materials is beyond the scope of this study.[1] This study focuses on the security of commercial radioactive sources because they represent a significant category of radioactive materials that are used widely throughout the world and, until recently, have not been considered high security risks.

A major finding of this study is that only a small fraction of the millions of commercial radioactive sources used globally, perhaps several tens of thousands, pose inherently high security risks because of their portability, dispersibility and higher levels of radioactivity. As a rule, these more dangerous

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This article is taken from the Executive Summary of the study of the same name, published as the Center for Nonproliferation Studies Occasional Paper no. 11, January 2003. The full study is available at <http://www.cns.miis.edu/pubs/opapers/op11/op11.pdf>.

commercial sources are those containing relatively large amounts of radioactivity (typically more than a few curies—greater than a hundred gigabecquerel—worth of radioactivity) of seven reactor-produced radioisotopes: americium-241, californium-252, cesium-137, cobalt-60, iridium-192, plutonium-238 and strontium-90. Some of these isotopes (americium-241, californium-252 and plutonium-238) would only pose internal health hazards by means of ingestion or inhalation, while the others would present both internal and external health hazards because the emitted ionizing radiation could penetrate the dead outer layer of human skin.[2]

To maximize harm to the targeted population, radiological terrorists would tend to seek very highly radioactive sources (containing tens of thousands or more curies) that pose external and internal health hazards. However, even suicidal terrorists might not live long enough to deliver an RDD because they might receive lethal acute doses of ionizing radiation from these sources in the absence of adequate shielding surrounding the radioactive material. But adding heavy protective shielding could substantially increase the difficulty in transporting an RDD and could dissuade terrorists from employing these types of sources. In contrast, sources that only present an internal health hazard and that contain very high amounts of radioactivity could be handled safely without heavy shielding as long as precautions are taken to minimize internal exposure.

While terrorist misuse of radioactive sources with low levels of radioactivity might cause a degree of panic for a brief period, the high-security risk sources are those that present genuine dangers to the public, in terms of long-term health effects and major financial loss. For this reason, this study concludes that properly regulating and securing this smaller subset of sources could contribute significantly to reducing the overall dangers posed by commercial radioactive sources. Public education, however, is also needed to familiarize the public with the RDD threat and, in particular, to provide, insofar as is possible, reassurance that some RDDs will have so little radioactivity as to pose little, if any, actual danger to the public.

This study finds that, unlike nuclear weapons, RDDs (including those using the seven radioactive isotopes noted above) are typically not weapons of mass destruction. Few, if any, people would die immediately or shortly after use of an RDD from exposure to the ionizing radiation from such a device, although, depending on its placement and size, many individuals might die from the conventional bomb blast if this method were used to disperse radiological materials. Most people not directly affected by the conventional blast would receive relatively low doses of ionizing radiation, even from weapons using the seven high-security threat radioactive isotopes, and possible cancer deaths would usually require years to decades to develop.[3] Nonetheless, an RDD can be a weapon of mass disruption or dislocation. Preying on the public's fears of radioactivity, terrorists who used RDDs would try to cause panic. The possible resulting chaos during evacuation of the immediate and surrounding areas of RDD use could not only cause injury and anguish, but could hinder emergency response efforts to assist the victims of the conventional blast. Moreover, the time needed for first responders to prepare to operate safely in a radioactive environment could add to delays in tending to these casualties. Further, the decontamination costs and the rebuilding costs, if necessary, from an RDD could be immense—perhaps upwards of billions of dollars. Therefore, while not causing the immediate, large-scale loss of life and physical destruction associated with nuclear detonations, RDD effects could be substantial.

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In addition, this study points out that only a few corporations, headquartered in a handful of nations produce most of the commercial radioactive sources that pose high security concerns. This small group then distributes sources to tens of thousands of radioactive source users throughout the world. The leading radioactive source producing nations are Canada, South Africa, the Russian Federation, Belgium, Argentina and France. In addition, the United States and the European Union

(EU) also play leading roles. Although the United States is not presently a major commercial radioactive source producing nation, it has the potential to re-emerge as one, and it contributes to a large market share of source use. The member states of the EU also use a significant portion of the commercial radioactive sources. This source production finding is significant because it indicates that by tightening export control standards and by conditioning exports on certification that effective security measures will cover the sources in recipient countries, some half-dozen exporting nations, together with the EU, could rapidly ensure that the considerable majority of high-risk radioactive sources in use around the world are properly protected against misuse. (As explained below, in discussing a major gap in current export control rules, implementing this change regarding importer-country regulations could be made in conjunction with a restructuring of the export licensing system that is needed for other reasons.)

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This finding is part of the study's broader analysis of the 'cradle to grave' stages of a radioactive source's lifecycle. All of the high-risk radioisotopes that are the active components of the sources of greatest security concern are created in nuclear reactors. These sources are then distributed to tens of thousands of global users. Ideally at the end of life, a source is safely and securely disposed of in a corporate or government-operated depository. Advanced industrialized countries use most of the high-risk radioactive sources, which are subject to regulation throughout their lifecycles. Traditionally, these regulations were concerned principally with protecting worker and public safety, rather than with securing high-risk sources against malevolent misuse, but these states are taking steps to address this gap. Indeed, this study finds that private industry and regulatory agencies in these industrialized countries have already taken steps to secure those commercial radioactive sources that pose the highest security risks, in particular, at reactors that produce commercial radioisotopes, in transit, and at the facilities employing the highest-risk sources. In other settings in these countries, industrial practices intended to protect sources as dangerous and valuable items provide an important measure of security against theft.

Domestic regulatory controls in the states of the former Soviet Union and in a number of developing countries are weaker or, in some cases, non-existent, and reforms (supported, as appropriate, by external assistance) are urgently needed in these places. In many of these states, however, the number of high-risk radioactive sources is more limited than in the advanced industrialized states. Therefore, intensive efforts to improve security over high-risk sources are needed for only a relatively small fraction of these sources worldwide, permitting efforts to be concentrated on this aspect of the radioactive source threat and offering the prospect of rapid improvement. By focusing its regulatory assistance programmes on many of the nations in this group, the International Atomic Energy Agency (IAEA) has helped develop new regulatory agencies or improved weak regulatory infrastructures. However, further improvement requires additional funding from IAEA member states that can provide it. Moreover, time and diligence are needed to instil a safety and security culture in nations that lack it.

Irrespective of the regulatory environment, this study points out that many end-users retain disused sources because of high disposal costs or lack of adequate depositories. These barriers to proper disposal create pressures on end-users to dispose of their high-risk sources outside of regulated channels, that is, to abandon, or 'orphan', them. Although major source manufacturers and many industrialized countries have programmes to sweep up disused sources before they are abandoned, these programmes should be expanded to mitigate this aspect of the risk posed by radioactive sources. Moreover, these efforts should concentrate on the high-risk radioisotopes. In addition, this study examines the dangers posed by previously lost or abandoned orphan sources. Although official reports and press accounts suggest that there are conceivably tens of thousands of such orphan sources worldwide, the study finds that of these, only a small fraction are in the high-risk category, with the preponderance probably to be found in the states of the former Soviet Union, as a legacy of the Cold War. By focusing resources on the high-risk sources (especially in the latter setting) significant progress can be made to reduce the worldwide dangers posed by orphan sources.

This study identifies a significant gap in US export licensing rules covering high-risk radioactive sources that could facilitate illicit commerce in these materials, a gap also seen in the licensing rules of a number of other developed Western states. Specifically, current US regulations permit the unlimited export of most high-risk sources under 'general' licenses, to all destinations, except Cuba, Iran, Iraq, Libya, North Korea and Sudan. Consequently, exports of these materials can be made without any governmental review of the bona fides of end-users, and exporters are not required to report on transfers of these materials. In other words, unlimited exports of cobalt-60, cesium-137 and other potentially dangerous radioisotopes incorporated in sources are permitted without any official review of end-users to many states where extensive terrorist activities are taking place—including all the states of the former Soviet Union, Afghanistan, Algeria, Columbia, India, Indonesia, Israel, the Philippines, Pakistan, Saudi Arabia and—to at least one state deemed by the US Department of State to be a state supporter of terrorism—Syria. Although the licensing authority, the US Nuclear Regulatory Commission, has taken interim steps (until permanent regulations are adopted) to intensify security at domestic sites where high-risk radioactive sources are used, it has not taken parallel interim steps to tighten export controls over these materials. (Separately, the Commission needs to intensify efforts to ensure the legitimacy of US end-users, when it grants domestic licenses for the possession of high-risk radioactive sources.)

Finally, this study examines a number of technical approaches, some of which are now being implemented, for reducing the dangers from radioactive sources. These measures include creating sources that are difficult to disperse, lowering the radioactivity level of radioactive sources, and developing non-radioactive alternatives for uses of radioactive sources.

Based on the above findings, this study urges high priority work in the following areas.

Protect against illicit commerce of radioactive sources by:

- Requiring specific licenses for exports of the high-risk radioactive sources to permit end-user reviews, beginning with the United States implementing and leading this effort.
- Maintaining strong domestic regulatory oversight of users of highly radioactive sources through verifying the legitimacy of the user before issuing a license to possess these sources and conducting more frequent inspections once a license is granted.
- Conditioning exports of high-risk sources on confirmation that the importing country has in place adequate controls and security measures; allow exceptions on humanitarian grounds, with case-specific safeguards.
- Continuing to enhance border and port security to prevent smuggling of illicitly obtained highly radioactive sources.

Dispose of the large pool of disused sources by:

- Developing, or ensuring adequate funding for, national programmes aimed at recovering disused sources from the public domain and placing them in secure interim storage. For example, the Off-Site Source Recovery Project operated by the United States Department of Energy has secured more than 3,000 disused sources, but the project faces a substantial funding shortage that, if not remedied, would cripple its ability to secure more than 10,000 additional disused sources that potentially pose a high security concern.

- Creating incentives for the prompt and proper disposal of disused sources, for example, by imposing a disposal fee to be paid when sources are acquired that would be partially refunded upon evidence of their proper disposition.
- Expediting creation of a permanent, secure disposal site in the United States for Greater Than Class C disused sources (which are long-lived and relatively highly radioactive sources that currently exceed regulatory standards for near surface disposal).
- Developing secure disused source depositories in countries that lack such facilities or in regional settings open to many contributing countries.

Address the outstanding problem of the thousands of radioactive sources that have been lost, abandoned or stolen—the so-called ‘orphan’ sources—by:

- Concentrating recovery efforts on the small fraction of orphan sources that pose a high security concern.
- Providing adequate funding for the United States Orphan Source Initiative, operated by the Environmental Protection Agency in conjunction with the Department of Energy and the Nuclear Regulatory Commission.
- Assessing whether adequate resources are being devoted to address the worldwide orphan source problem.
- Prioritizing finding and securing high security risk orphan sources in the Newly Independent States. In particular, the United States, the Russian Federation and the IAEA should ensure that their recently launched tripartite initiative to secure orphan sources in the Newly Independent States remains a top priority.

Assist the approximately 100 nations—about half the world’s total number—with weak regulatory controls, starting with those having the greatest number of high-risk radioactive sources, by:

- Expanding the IAEA’s regulatory assistance efforts, which have been successful in building up the regulatory infrastructure in several IAEA member states. Moreover, all member states should adhere to the Code of Conduct on the Safety and Security of Radioactive Sources, which is currently being revised to focus more on security concerns.
- Offering regulatory and security assistance to the approximately fifty non-member states of the IAEA that possess radioactive sources, but lack adequate regulatory infrastructures. The leading radioactive source producing nations should consider providing this assistance.

Reduce security risks from future radioactive sources by:

- Encouraging producers to make sources that are relatively difficult to disperse. For example, reduce the production of powdered cesium-chloride.
- Continuing to reduce the radioactivity levels of sources to the minimum required to perform the necessary, beneficial task.
- Promoting the use of non-radioactive alternatives to radioactive sources (such as accelerators),[4] where those non-radioactive methods can provide the same or greater benefit as radioactive sources.

Mitigate the potential effects of RDD use by:

- Educating the public and the press about the hazards and appropriate responses to the use of an RDD.
- Preparing first responders by providing radiological training and equipment.
- Conducting regular emergency planning exercises involving coordinated efforts of local and federal officials, and applying lessons learned from these exercises to develop more effective response capabilities.
- Investing in research and development of effective decontamination technologies.
- Investing in research and development to enhance the protection, detection and tracking of radioactive sources.

In addition to reducing the risks from RDDs, these recommended measures will improve radiation safety and, thereby, enhance public health. Through continued attentive effort, clear vision of priorities, and focused initiatives, governments, international organizations and industry can meet the challenge of the potential misuse of highly radioactive sources by terrorists.

Notes

1 The Center for Nonproliferation Studies intends to publish in the near term a systematic, comparative analysis of the major aspects of nuclear and radiological terrorism. The forthcoming report will examine the security risks posed by all relevant radioactive materials.

2 Strontium-90 would primarily present an internal health hazard.

3 Under certain highly specialized scenarios, it is possible to imagine many thousands of individuals receiving small ionizing radiation doses that could ultimately prove lethal over a long time period. For this reason, under some circumstances, RDDs could result in mass long-term casualties, making them weapons of mass destruction of a unique variety, but ones unlikely to be attractive to terrorists.

4 Non-radioactive alternatives, such as accelerators, which generate radiation by accelerating charged particles, only produce radiation when an electrical power supply is turned on and do not pose a radiological dispersal device threat.

The implications of 11 September for the nuclear industry

John H. Large

The acts and motives of those terrorists who attacked the United States on 11 September 2001 were met with astonishment and disbelief. Perhaps this was because we had come to expect a limit on the level of outrage as terrorists have acted mainly within their own constituencies thereby applying a degree of self-restraint. However, with its attacks in the United States al-Qaeda demonstrated that it was prepared to operate outside its ill-defined constituency, being free to strike at international targets, exclusive of restraints and, with the attacks in Washington and New York, intended to maximize the loss of life and human suffering.

The other disturbing element of the al-Qaeda atrocity was that the terrorists themselves did not need to manufacture any technological device for they simply pitted one available technology (fully fuelled commercial airliners) against another (commercial office building structures). In doing so, they outwitted the designers and operators of these two diverse technological systems—neither had recognized that one could be deployed against the other with such devastating effect.

After the events of 11 September, it is perhaps just a short and logical step for terrorists to latch onto how highly hazardous nuclear plants might be triggered into releasing energy and toxins via aerial and other modes of terrorist attack. If this happens, can such plants provide a robust defence against terrorist attack and are there particularly vulnerable parts of the buildings and processes that, if penetrated, could lead to a devastating release of energy, toxins and radioactivity?

Nuclear plants and processes

Nuclear plants undertake a variety of processes, some of which involve intensely radioactive materials and highly reactive chemicals. Moreover, being nuclear there is a public perception of dread and fear (i.e. a fate worse than death) associated with radioactive release. Even if sometimes the public's perception of all things nuclear can be exaggerated, by virtue of this fear, the socio-psychological impact of a nuclear terrorist attack might be much greater, thus rendering nuclear plants even more attractive to terrorists.

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To mount an attack on a nuclear plant the terrorist cell would have to plan ahead, locate the particularly hazardous processes and stores, determine the amount and nature of the radioactive contents and how readily this might be dispersed into the atmosphere, and identify the most vulnerable aspects of the buildings and containments of the targeted plants.

Examining how and by which means those planning such a hypothetical act of terrorism might obtain this sort information and, from this, how potential target systems and processes within a nuclear plant can be identified leads to a disturbing outcome.

This is that both nuclear power stations and nuclear fuel plants (such as Sellafield in the United Kingdom) are almost totally ill-prepared for a terrorist attack from the air. For example, at Sellafield the design and construction of the buildings date from a period of over fifty years, many of the older buildings would just not withstand an aircraft crash and a subsequent aviation fuel fire, and some of the buildings, now redundant for the original purpose, have been crudely adapted for storage of large quantities of radioactive materials for which they are clearly unsuited. Even the design of the most modern nuclear plants does not seem to provide that much defence (in terms of containment surety and segregation of hazardous materials) against terrorist attack.

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Overall, the nuclear industry defends its plants against natural and accidentally occurring hazards on a basis of 'as chance would have it', and it provides protection against human error by designing the systems and equipment to be tolerant and/or independent of human action (or inaction). This combined approach of gauging the risk by probabilistic assessment and treating the human operators as inconsequential dummies may have some effect in safeguarding the plant against accidents, natural hazards and unintentional human error, but it may prove to be woefully ineffective against intentional and intelligently driven acts of terrorism.

Terrorist attack

It is an unwitting trap to assume the future *modus operandi* of a terrorist attack will follow the pattern the airliners hijacked by al-Qaeda on 11 September in the United States. Simply strengthening airport security may deter aviation terrorism for the time being and, indeed, there may have already occurred a shift towards tourism targets with the dreadful bombings at Bali and Mombassa.

So a malicious attack on a nuclear plant could be applied via a variety of means including, for example, armed insurgents forcibly entering and interfering with the plant safety systems, from an external explosive device such as a truck or four-wheel drive vehicle bomb being detonated just outside the plant's secure area, or via a passive or an active insider employed within the plant itself. Indeed, these shifts in themselves might suggest that the terrorists may be seeking out and exploring new targets and their impact.

For now, consider the terrorist attack to be centred on an airliner hijack. In assessing *accidental* aircraft crash probability the guidelines and principles set out by the United States Department of Energy[1] are generally adopted worldwide. Essentially, this approach assumes some form of loss of control of the subject aircraft, its subsequent deviation from the intended flight path and the chance of it crashing into the nuclear plant. The nuclear plant is defined as a crash area in terms of its size, locality within the terrain and the projected height of the buildings above ground level. Applied to a civil airliner operating at altitude and passing along a prescribed flight path, this *a posteriori* probabilistic approach adopts rates drawn from actual crash incidents, which yield very low accidental crash probabilities. Essentially, the whole probabilistic assessment outcome is determined by the chance of a very small missile (a commercial airliner) accidentally hitting a small target (the nuclear plant) located in a very large geographical space. Much the same approach is adopted for other accidental and naturally occurring hazards—be it a road vehicle laden with petroleum spirit running out of control into the plant, or a freak tsunami inundating the nuclear site—which will also result in extremely low and improbable chances of occurrence.

Applying this to nuclear plants suggests that *accidental* aircraft crash rates are sufficiently low (less than one in ten million per year) to satisfy the requirements that the hazard occurrence is so remote that it cannot be expected to affect the plant. Put simply, this probabilistic approach has led to plant defences against accidents and natural hazards being based on repelling or coping with events that might be best described as *unintelligent* and *unintentional*, some of which are considered to occur, as chance would have it, so infrequently that the time, trouble and cost of implementing countermeasures are not justified.

Of course the probability or chance of the occurrence of a malicious human act, such as the terrorist attack of 11 September, cannot be determined by classical *a priori* probabilistic means. This is because terrorist attacks are *intentional* (overriding probability), which have to be considered to be *intelligent* and *intentional* events that will seek out the vulnerabilities of the target system.

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Notional restraints such as no-fly zones nearby nuclear plants are to no effect once an aircraft has been commandeered and the terrorist attack is underway. If the terrorists fly to the targeted plant by line of sight (apparently the case for the World Trade Center), then visual contact at cruising altitude is achieved at about thirty miles (48km), which leaves but an impracticably short timescale (four to five minutes) for the authorities to detect, intercept, interrogate and implement the appropriate remedial action to thwart the attack. As notional restraints would be useless to deter an attack once it had started, the sole remaining option to handle the crisis is consequence mitigation.

Consequence mitigation

Two points must be kept in mind when attempting to defend nuclear plants and facilities against attack.

First, the design and construction of the buildings of these sites were likely to comply with the regulations and good practice of the times, being considered then 'fit for purpose'. So, even if the designers of the day had included within the building and containment designs (and processes within) features resistant to aircraft crash, the assessment would have related to the types of aircraft flying at that time. Similarly, the need or priority to incorporate such features would have sensibly related to the density of aircraft traffic at that time, that is, the probability of a crash event. Second, for those plants designed and regulated from a probabilistic basis, it is very doubtful indeed that any intentional aircraft crash resistance was built into the system—not just for the building structures and physical containments, but also on the resistance of safety equipment to resist impulse loading and the fire associated with aircraft crash.

Put another way, the generic designs of nuclear plants were set down in the 1950s and 1960s when commercial aircraft were typical of the relatively small size of a Vickers Viscount and similar. Today, there are no longer any Viscounts in commercial service yet all of the nuclear plants of those bygone times remain, most continuing in operation.

These two inconsistencies alone suggest that it would be impracticable for the world's nuclear plant operators to modify much of the existing plant so that it would be reasonably guaranteed to survive an aircraft crash. The severity of an aircraft crash might drive through and render ineffective the normally accepted physical systems that serve to limit the consequences, such as safe shutdown, continued availability of utilities, adequate containment integrity and on- and off-site emergency preparedness. If so, the accident would still have to be 'managed' by improvising the use of other surviving systems and resources, which requires an increased reliance upon operator intervention because accident management strategies must be implemented by plant personnel.

The severity of an aircraft crash might drive through and render ineffective the normally accepted physical systems that serve to limit the consequences, such as safe shutdown, continued availability of utilities, adequate containment integrity and on- and off-site emergency preparedness.

Nuclear plants are designed to withstand, as far as is practicable, specified external hazards such as earthquakes, flooding, etc., but this defence is quite scenario-specific and the capability of certain items of equipment to survive depends not only on the custom engineered resistance to particular scenarios but, importantly, on the diversity of function of the safety systems and equipment involved. The point here is whether the diversity of the installed equipment is sufficiently broad to resist a common mode failure across all of the equipment and systems that could be triggered by aircraft impact, fuel explosion[2] and the subsequent fire.

Also, it is doubtful that the outcome of a consequence analysis could be practicably implemented to provide an effective consequence mitigation management regime. Moreover, accident management, even if performed as planned, might prove ineffective—leading from one severe accident sequence to another just as hazardous and it may, in certain rapidly developing situations, be counter-productive.

Impact and ensuing fire of an aircraft crash

Aircraft, for all of their speed and power, are relatively fragile structures. The 190 or so tonnes of each Boeing 767 that ploughed into the twin towers of the World Trade Center may have provided a colossal kinetic energy but the wings and fuselage would have shredded almost immediately, leaving just the compact masses of the engines and a few solid spars and undercarriage frames in the role of very energetic projectiles to penetrate the building structure. Accompanying this high-energy impact was the release of the 80,000 litres or so of aviation fuel, partially vaporized, that erupted into fireballs to ignite flammable materials in the vicinity.[3] Vaporized and unburnt fuel would have been squeezed into building voids by the expanding flame and pressure fronts and the remaining fuel would have gushed into the interior of the building, spreading downwards through buckled and holed floors. As the tragedy unfurled it was clear within minutes that about ten floors of each of the towers were burning furiously, so intensely that the structures buckled and progressive collapse commenced on the South Tower within one hour of the aircraft impact.

Now that a full analysis of the collapse of both the World Trade Center towers and the Pentagon has been published,[4] it is clear that both the impact and the fire phases of the crash played active roles in the destruction of the buildings. The initial impact would have destroyed or weakened the structure of the buildings and the immediately following fire was of sufficient temperature to ignite all flammable materials within, which provoked further structural member buckling and damage leading to catastrophic structural failure.

Failing the engineered structures of nuclear power plants

Obviously, the effect and outcome of an aircraft crash and fuel explosion/burning on any one of the active plant buildings or processing/storage areas of a nuclear power station would be subject to how each of the individual target buildings would perform under the impact and fire conditions.

The results of aircraft impact can be segregated into two regimes. First, at the moment of impact the aircraft can be considered to be a very large but relatively 'soft' projectile which, by 'self-deformation' will dissipate some fraction of the total kinetic energy being transferred during the impact event. Second, some components of the aircraft will be sufficiently tough to form rigid projectiles that will strike and commence to penetrate, again by kinetic energy, components of the building fabric and structure.

Setting aside localized damage in which individual structural components are removed (blasted away), the most probable failure mode of the structure overall is that of buckling and collapse in response to the impact. The types of building structures featured at nuclear power plants, for example the radioactive waste and spent fuel buildings, would not withstand the impulse magnitude delivered by a crashing commercial aircraft. Even if the building structures remain standing, relatively small and localized penetration by parts of the breaking-up aircraft will permit the inflow of aviation fuel with the almost certain fire aftermath—which, in itself, will heighten the release and dispersal of any radioactive materials held within the building structure.

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It is quite reasonable to assume that the building containment would be breached—this is likely to be a justified assumption because of the absence of any extraordinary civil engineering features visibly incorporated into the building design. On this assumption, once that the building is breached it may be that the particular process and/or substances stored within will add to the damage, by explosion and ferocity of the fire (flammables).

Damage and consequence scenarios

For a typical nuclear power plant, the following scenarios might arise.

Irradiated (spent) fuel storage

If the roof structure of the covered fuel ponds was penetrated and the pond wall structure breached, then the loss of pond water and the aviation fuel fire could lead to a breakdown of the fuel cladding and fuel itself, resulting in a high release fraction of fission products, possibly mixed with emulsions of the aviation fuel. The fuel pond radioactive inventory depends on the degree of irradiation of the fuel (the burn-up) and the post in-core period, although the quantity of fuel might represent (in mass) seven to eight times or more the reactor core load.

A crashing airliner, displacement of the fuel pond water and introduction of burning aviation fuel could result in a very significant radioactive release from the irradiated fuel pond. The subsequent dispersion range of the airborne radioactivity could be much enhanced by the high thermal energy involved (plume height) and combination of fission products with emulsions of the aviation fuel and its products of combustion.

Intermediate radioactive wastes

The radioactive inventories and chemical make-up of the stored radioactive wastes at nuclear plants sites is known and because of the dilemma over failure of most nuclear countries to find a national radioactive waste repository for high- and intermediate-level categories of radioactive waste such wastes will accumulate at the individual nuclear sites for the immediate and interim futures.

Certain nuclear sites carry a high burden of radioactive wastes. At the fuel reprocessing plant at Sellafield, for example, there are very large volumes in store, some of which are flammable in themselves, such as the 1,000m^3 or more of contaminated reprocessing solvent (odourless kerosene) which could add considerably to the aftermath fires of an aircraft impact. Ignition and/or chemical reaction of the radioactive wastes could serve to further increase the quantity and efficacy of the radioactive release.

Operational nuclear reactors

The range of potential outcomes for operational reactors subject to terrorist attack is large.

Obviously, a direct impact on the reactor locality, breaching the reactor pressure vessel and/or the primary coolant circuit would most probably result in a radioactive release into and through the secondary containment systems that would have also been breached by the impacting airframe. Other safety-critical equipment of operational nuclear power plants include the electricity supply grid connections and the emergency diesel electricity generators, both of which provide essential electrical supplies for safety systems, reactor cooling and heat sinks, and the loss of which, particularly effective core cooling, could result in containment challenging events developing in the reactor core.

The main findings arising from these scenarios are that:

- very few, if any, of the world's nuclear reactors have containment that has been specifically designed to resist aircraft attack, although some are designed with a secondary containment dome to resist an accidental impact of a light aircraft;
- none of the radioactive waste and spent fuel facilities, at the nuclear power plants and fuel plants such as Sellafield, could withstand the directed impact of a fully loaded commercial airliner; and
- many of the radioactive waste and fuel storage facilities, again at the nuclear power plants and at Sellafield, contain massive amounts of radioactive material available for suspension and dispersal in the aftermath of a terrorist attack.[5]

Concerns

With these scenarios in mind, this paper poses three queries.

- Is there sufficiently detailed information available in the public domain for a terrorist group to plan an attack with sufficient confidence of success?

- Does the regulatory safety case requirement include for *accidental* aircraft crash and, if it does, is this sufficient to safeguard against *intentional* aircraft crash?
- Could the plant's systems and processes be modified and prepared to withstand such an intentional attack and, if so, how much of this defence would depend upon accepting intentional aircraft crash as inevitable, thereby relying almost totally upon consequence management to mitigate the outcome?

Information accessibility

Using the plants in the United States and the United Kingdom as yardsticks, it is relatively straightforward to obtain all of the information a terrorist would require by simply accessing publicly available documents. Ministries and agencies of central governments publish most of these sources of quite detailed information, and local authorities maintain records of planning applications that include details of extant as well as proposed plants and buildings. These records and documents are readily accessible, it being possible to obtain copies directly from the originating department of documents from the 1990s and earlier.

Also, there are a number of 'storehouses' of related information. Local, national and international environmental (and other) groups hold pools of information that they have accumulated over the years. As example, one local group was able to provide photographs of locations deep within the Sellafield fuel reprocessing site, and elsewhere fully detailed engineered drawings of buildings, and scaled site maps that included the location of essential services, are available for the UK Sizewell B pressurized water reactor from the Construction Report prepared for and published at its preconstruction Public Inquiry.

For example, when responding to requests for information and documentation, both the British government and the relevant local authority did not enquire to what purpose the information was required and, during my firm's requests, there seems to have been no verification of the bona fides and identity of the enquirer.

Within two weeks of the 11 September attacks, the United States Nuclear Regulatory Commission (NRC) closed down all of its Internet web sites to review the contents; surprisingly, the web pages relating to Sellafield (British government, BNFL, etc.) remained open and accessible.

Aircraft crash and design basis threats

Although this paper centres on an *intentional* aircraft crash, a future terrorist attack against a nuclear plant might be in the form of some other external, man-made hazard. However, here I have only considered aircraft crash in any detail, although a future terrorist incident might involve, for example, a truck bomb driven close to or actually into the plant secure area.

Arising from the history of considering only accidents and natural hazards for in-plant defence, the worldwide nuclear industry is almost dismissive of the risk solely on the basis that the calculated frequency renders such an *accidental* event to be entirely incredible and, hence, there may have been little incentive to include for such a remote event in the plant's design. Now, in the post-11 September era, the unpalatable likelihood of an intentional aircraft crash into a nuclear plant has to be considered and accounted for as a Design Basis Threat (DBT).

The worldwide nuclear industry is almost dismissive of the risk solely on the basis that the calculated frequency renders such an* accidental *event to be entirely incredible and, hence, there may have been little incentive to include for such a remote event in the plant's design.

For other DBTs, such as truck bombs and attacks by armed insurgents, the NRC requires American nuclear plant operators to submit to force-on-force trials simulating intentional malicious actions. Since 1991, the NRC has conducted about ninety trials or *Operational Safeguards Response Evaluation* tests, of which about 45% of the tested nuclear plants failed. Most disturbing is that three plants tested shortly before 11 September (Farley, Oyster Creek and Vermont Yankee) received results that were the worst on record. In another assessment, the NRC notes that between 15 to 20% of nuclear plants in the United States would sustain safety critical levels of damage from vehicle bombs accessing close to the supervised boundary of the plant.[6]

Although some British nuclear plants have been subject to mock attack exercises, nothing on their vulnerability and/or performance has been published. Recently (May 2002), however, Bradwell nuclear power station was subject to some form of trial which involved the local authority emergency planning resource and which must have involved the central government Department of Trade and Industry's Office for Civil Nuclear Security (OCNS).

Apparently (because nothing is publicly available), OCNS has evolved a new procedure to assess security threats, which are to be incorporated into a DBT document. This document is to be the key planning aid for plant operators. The DBT will provide intelligence about the 'motives, intentions and capabilities'[7] of potential adversaries against which the plant operator is to 'beef-up' the plant management, contingency planning and physical security measures. Once all of this is in place, the Director of the OCNS will evaluate the robustness of each of Britain's individual nuclear plants; this information was to be made publicly available in the OCNS's first annual report.[8]

At the governmental level in the United Kingdom, there is the recently formed Chemical, Biological, Radiological and Nuclear (CBRN) cabinet sub-committee. The role of CBRN is to review the contingency arrangements in place to protect against terrorist attack, although its findings are classified restricted and above, and nothing is publicly available on its membership and how and to whom it communicates its recommendations.

At local level, local authorities are presently preparing off-site plans as required by the government's Radiation (Emergency Preparedness & Public Information) Regulations (REPPIR). For this the nuclear plant operator is required to prepare a Report of Assessment upon which the Health and Safety Executive (HSE) determines the need and coverage of any off-site emergency planning. REPPIR was prepared and enacted before the events of 11 September so, not surprisingly, it is silent on the specific need to include DBTs in the Report of Assessment. Indeed, the overseeing government agency (HSE) considers it unnecessary to specifically plan for terrorist acts since both the probability and mode of attack are not 'reasonably foreseeable' and, in any event, it assumes that the local authority off-site plans are extendible to cover such acts. Just how and to what effectiveness poorly resourced local authorities would deal with a terrorist attack in the United Kingdom, particularly if the terrorist also harried the implementation of the off-site countermeasures, remains a matter of conjecture.

Like many other nuclear countries, Britain has been jarred into action by the events of 11 September. New committees have been formed, assessments are being made and there is now, via REPPIR, a real opportunity to put in place—resources permitting—effective emergency planning and consequence management measures.

It has to be acknowledged that modifying the existing plants to improve their physical invulnerability is just not practicably feasible.

However, it has to be acknowledged that modifying the existing plants to improve their physical invulnerability is just not practicably feasible. In place of this, there must be effective intelligence gathering on the ground in advance of any planned attack and this must be communicated to the operators and the emergency planners.

Although informed in advance of the threat, the Bush Administration was unable to thwart the 11 September attacks. A similar failure in acting upon gathered intelligence could not be tolerated again, particularly if it was believed that a nuclear plant had been identified as a target.

Defending nuclear plants—consequence management

In summary, nuclear plants are poorly prepared for a terrorist attack from the air. Many of the buildings would not withstand an aircraft crash and subsequent fire. Even the design of the most modern plants does not seem to provide that much defence (in terms of containment surety, dispersion of stocks to different localities, and segregation of hazardous materials) against an aerial attack.

It would not seem to be practicable for each and every building and process at such nuclear plants to be modified to provide adequate protection against aircraft crash. The investment required would be enormous and the practical difficulties challenging indeed—many of the processes would have to be relocated, possibly to underground caverns and bunkers, which in itself might introduce other safety related detriments. Nor would this change the fact that an intentional airline crash is but one of numerous scenarios that would disrupt the functioning and safety of a nuclear plant or facility.

If a terrorist group planned to intentionally crash an aircraft onto a nuclear power station then the probability of the event becomes a certainty and it is inappropriate to mitigate the chance of such an intentional attack occurring by probabilistic based assessment. Considering an intentional aircraft crash as a certainty, rather than as some remote probability, requires the event to be assessed in terms of its consequence management alone and this consequence management is the only form of mitigation available. In other words, there are no practicable measures that might be implemented on-site to provide a defence in depth to avert such an event.

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However, the idea that a severely damaging event, arriving like a bolt out of the blue, could be ‘managed’ by improvising the use of other systems and resources is doubtful, particularly because ad hoc decisions and actions (taken in unpractised and highly stressed situations) might lead from one severe condition situation to another just as hazardous.[9]

Conclusion

Most nuclear plants worldwide were designed and constructed without direct concern for a terrorist attack. These plants are huge, complex structures housing sophisticated processes that can rapidly degrade to chemical and nuclear instability. Forceful interference with the physical containments and the safety and control systems of a nuclear plant by terrorist action could result in a massive release of radioactivity into the environment, spreading for tens if not hundred of kilometres from the nuclear site. The resulting human suffering could be immense, at a Chernobyl scale, perhaps crossing national borders, involving thousands of individuals, contaminating vast areas of land in the long-term—the social and economic consequences could vastly outstrip the impact of the terrorist events of 11 September.

That said, there is little that can be done to strengthen the defence of these plants against terrorist attack. To resist aerial attack, the only practicable recourse is to increase vigilance at airports to prevent terrorists from boarding, but this would have to apply worldwide in states that might be thousands of kilometres from the targeted plant. If terrorists were effectively prohibited from boarding at airports, their modus operandi might switch from air to attack by truck bomb. If the plant perimeter was strengthened and expanded to resist this mode of attack, then the vulnerability of the plant to an insider or fifth columnist might be exploited, and so on and so forth.

The choice of solution to this problem (if, that is, a solution exists) is not at all easy. It has to be accepted that whatever measures are implemented to improve the defence of existing nuclear plants that once a determined terrorist group or individual has identified its target, it might get through. If there is a solution it is surely a combination of addressing the underlying fundamental conflicts that drive terrorism, together with both states and peoples maintaining an eternal vigilance which is, after all, the price of liberty.

References and notes

1 United States Department of Energy, 1996, *Accident Analysis for Aircraft Crash into Hazardous Facilities*, DOE-STD-3014-96, available at <http://tis.eh.doe.gov/techstds/standard/std3014/std3014.pdf>; see also for practical application United States, Nuclear Regulatory Commission, 1981, *NUREG-0800, Section 3.5.1.6 Aircraft Hazards*, Nuclear Regulatory Commission, which suggest a crash rate in the absence of other data to be $3.66x10^{9}$ per flight mile. The great majority of nuclear power plants worldwide are based upon American designs so the approach of the United States to accidental aircraft crash is generic in all of these plants.

2 Commercial jet fuel typically has a heat of combustion of about 38 MJ per litre against, for comparison, 4.2 MJ of energy for the same mass of TNT. If conditions are right, some part of the combustion process of the aviation fuel during the impact could be in the form of a fuel-air explosion which could be quite violent, generating a high energy blast wave which could add to the destruction (locally and in addition to the impulse loading of the impact).

3 The fuel load and aircraft mass could be significantly larger. For example, applied to Sellafield there are about 250 flights of Boeing (Jumbo) 747 airliners per week passing over the northwest region of England. Flying from Amsterdam a Boeing 747 would commence its flight with about 175 tonnes of aviation fuel and fuel consumption for taxiing, take-off, climb and cruise to Sellafield would leave about 155 tonnes of fuel at impact.

4 American Society of Civil Engineers (ASCE) for the Federal Emergency Management Agency (FEMA), 2002, *World Trade Center Building Performance Study: Data Collection, Preliminary Observations, and Recommendations*, available at <http://www.fema.gov/library/wtcstudy.shtm>.

5 For example, at Sellafield there is in store, in powdered dioxide form, approximately seventy-two tonnes of plutonium-239 which has been recovered over the years from irradiated fuel reprocessing. This plutonium stockpile is stored in two adjacent buildings—details of which have been readily accessible from the local planning authority.

6 E. Lyman, 2002, *Terrorism Threat and Nuclear Power: Recent Developments and Lessons to be Learned,* International Symposium on Rethinking Nuclear Energy and Democracy after 09/11, PSR/IPPNW/Switzerland, Basel, April, available at <http://www.nci.org/PDF/Lyman.pdf>.

7 Sunil Parekh, Assistant Private Secretary to John Denham, Home Office Minister, 10 May 2002.

8 The OCNS's first report has now been published but it contains no details whatsoever about the performance of the individual nuclear power plants, although it notes that it itself is experiencing staffing difficulties that do not permit it to carry out its function completely.

9 This paper has concentrated on nuclear plants and processes on a nuclear site itself. It should also be noted that a nuclear plant depends upon the continuous import of services, particularly electricity and mains water, to maintain safety on the site, and—if imported electricity supplies fail—solely on the on-site emergency plant supplies. These imported services (the national grid electricity lines, emergency generators and water pipelines) may also be susceptible to terrorist attack.

FM(C)T benefits and burdens: today's needs, tomorrow's opportunities

Thomas E. Shea

Ten years ago, the United Nations General Assembly approved a resolution calling for the negotiation of a 'non-discriminatory, multilateral and internationally and effectively verifiable treaty banning the production of fissile material for nuclear weapons or other nuclear explosive devices'.[1] Eight years ago, the Conference on Disarmament (CD) agreed upon a negotiating mandate,[2] and five years ago, an ad hoc committee was established for a brief period to commence work on the treaty.[3] In most years since then, the United Nations General Assembly reiterated its support for this treaty,[4] and every Review Conference of the Treaty for Non-Proliferation of Nuclear Weapons (NPT) has called for its negotiation before the next Review Conference.[5] Aside from the Shannon Mandate and the short-lived ad hoc committee in 1998, the CD has not been able to agree upon a work plan and there has been no work on the negotiation of this prospective treaty.

One reason for this lack of progress may be the perception that the benefits expected from the treaty have not been seen by many as commensurate with the anticipated burdens (negotiation complexity and implementation costs). But times change and today's threats of proliferation and nuclear terrorism warrant another look at the FM(C)T.[6] Appropriately cast, a treaty banning the production of fissile material for the manufacture of nuclear weapons or other nuclear explosive devices could provide a starting point for important progress towards nuclear disarmament, strengthen the international non-proliferation regime and help to prevent nuclear terrorism.

The basic premise is that fissile materials remain essential for all nuclear weapons. Thus, controls on the production and use of fissile materials serve as the foundation of the international non-proliferation regime and the prime focus of International Atomic Energy Agency (IAEA) safeguards.[7] Similarly, controls on fissile materials in relation to nuclear disarmament would inhibit expansion of existing arsenals and provide a means to lock-in arms reductions. It would also help to create the confidence necessary for successive steps towards the eventual elimination of nuclear weapons.

The task of banning future production of fissile materials for use in nuclear weapons or other nuclear explosives connects this treaty to the existing non-proliferation regime. It provides a means to guide future peaceful nuclear applications in directions that will not encourage nuclear ambitions by any state or sub-national body.

Thus, a treaty banning the production of fissile material for nuclear weapons or other nuclear explosive devices merits a new look to see how such a treaty could allow international verification related to nuclear disarmament while extending and bolstering the existing non-proliferation and physical protection regimes.

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Nine potential elements of a future FM(C)T

If a treaty banning the production of fissile material for the manufacture of nuclear weapons or other nuclear explosive devices were to incorporate the nine elements identified below, the treaty and the regime it creates would be vital to international security.

Element 1. Verify former military production facilities to confirm that they have ceased operations, or have been converted to peaceful applications or non-explosive military applications:

- high enriched uranium (HEU) enrichment plants;
- plutonium reprocessing plants; and
- plutonium production reactors remaining in operation following entry into force.

This element of the FM(C)T would stop the production programmes that have supported today's nuclear arsenals, and thereby establish a cap (except for imports) on the inventories of fissile material available for use in a nuclear weapons programme. This element would have essentially no impact on states that are currently subject to a comprehensive IAEA safeguards agreement, because those states are already prohibited from producing fissile material for non-peaceful purposes, and are subject to *de jure* requirements to place all of their nuclear materials under IAEA safeguards.[8]

This element would focus on the past.[9] It would call for all of the facilities that were used to produce fissile material for nuclear weapons at any time in the past to be declared, and upon entry into force of the treaty, to be shut down or converted to peaceful use (or for a non-proscribed military purpose).

Through this element, all enrichment plants and reprocessing plants used for military production would become subject to inspection to ensure that they remain shut down or are reconfigured and operated henceforth exclusively for peaceful (or non-proscribed military) purposes. Any fissile material produced after entry into force would be verified to confirm that it is not used to manufacture nuclear weapons or other nuclear explosive devices, and would remain accounted for under the treaty until specified termination criteria have been met.[10]

If these enrichment plants and reprocessing plants were shut down, the monitoring activities would be simple and inexpensive. Depending on the effort required to resume operations, for example, the monitoring operations could be carried out without the need for frequent inspection visits or installed monitoring equipment. Satellite imagery or remote monitoring might also be employed. However, if those enrichment or reprocessing plants remain in operation under the FM(C)T, the monitoring costs and complexities would be much greater, particularly for reprocessing plants. Recognizing that these facilities are located at sensitive sites and that activities related to nuclear weapons may continue in other facilities at the same sites, the monitoring activities, including the equipment to be used, may need to be developed and applied under special arrangements that provide assurance to the state that the monitoring operations do not serve an unintended purpose.

Element 2. Verify all fissile material produced for peaceful use *after* entry into force:

- civil reprocessing plants;
- uranium conversion and enrichment plants;

- conversion / fuel fabrication plants for fissile material;
- reactors fuelled with fissile material;
- hot cells; and
- waste conditioning plants and geological repositories.

Certain peaceful nuclear operations produce fissile material under normal conditions that would be suitable for use in manufacturing nuclear weapons or other nuclear explosive devices. Thus, under the FM(C)T, it would be necessary to verify that *all* fissile material produced in peaceful nuclear programmes *is declared and accounted for*, and thereafter, to assure that the fissile material is not diverted to weapon use.

The benefits of bringing these 'civil' facilities under verification would be extensive. All reprocessing and enrichment facilities would be subject to essentially the same inspections, and the requirements for rigorous practices would ensure that these facilities and the fissile materials that are produced, processed and used are subject to universal, state-of-the-art material control and accounting requirements. These material control and accounting systems constitute the first line of defence against threats of theft, and thus the material control and accounting practices necessary for the FM(C)T would also serve a direct benefit in relation to the prevention of nuclear terrorism.

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The experience gained in applying IAEA safeguards in non-nuclear-weapon states (NNWS) would be directly applicable. In addition, as the states possessing nuclear weapons gain experience and skill in the accounting and measurement systems and the containment and surveillance methods applied under the FM(C)T inspections, they would be able to adapt those practices to other activities that would not be subject to inspection.

For most of the states possessing nuclear weapons, this element of the FM(C)T would be the most expensive, by far. The costs for IAEA safeguards are currently on the order of US $100 million per year. Given the extensive range of civil nuclear operations in the states that are not subject to comprehensive IAEA safeguards agreements, similar costs should be anticipated for this element of the FM(C)T. [11]

While inspections of civil facilities will be expensive and burdensome, recall that all similar facilities in NNWS are already subject to IAEA inspections. The objective of IAEA safeguards is to detect the 'diversion of significant quantities of *nuclear material* from peaceful nuclear activities to the manufacture of nuclear weapons or of other nuclear explosive devices or for purposes unknown, and deterrence of such diversion by the risk of early detection.'[12] In fact, the definition of 'nuclear material' is broader than that for 'fissile material' and thus the inspection burden would still be more demanding on NNWS than foreseen under the FM(C)T in states possessing nuclear weapons.

Element 3. Verify the absence of undeclared production of fissile material within the facilities that are submitted for inspection; verify the absence of clandestine facilities; and verify that specialized equipment/material remains dedicated to peaceful use (including dual-use equipment).

Following the discovery of the clandestine nuclear programme in Iraq in the early 1990s, the ability of IAEA safeguards to detect undeclared production of fissile material in existing facilities and in clandestine facilities was strengthened. Additional safeguards activities were introduced in declared facilities, including the verification of design information to confirm that the facilities are designed and operated in accordance with information provided by the state, and environmental sampling to detect indications of undeclared operations.

Verification activities undertaken to detect facilities that are not declared (i.e., clandestine facilities) involve satellite imagery, extensive information analysis, and complementary access to locations not associated with declared facilities. The Additional Protocol to IAEA Safeguards Agreements provides a legal basis for the IAEA to carry out such activities in NNWS, and should be a part of the verification for all states parties to the FM(C)T. [13]

The verification costs for confirming the absence of clandestine facilities will be far less than the verification activities at declared facilities. Verification activities undertaken to detect clandestine facilities in states possessing nuclear weapons and naval propulsion reactors may have to be more restricted than in NNWS to prevent inspectors from acquiring protected information pertaining to the design or manufacture of nuclear weapons.

Element 4. Verify existing plutonium and HEU stocks from peaceful nuclear programmes to prevent their use in nuclear weapons or other nuclear explosive devices.

If the FM(C)T is to limit the availability of fissile material for use in the manufacture of nuclear weapons or other nuclear explosive devices, then existing stocks from civil nuclear operations should be subject to verification under the treaty. If not, the cap established upon entry into force of the FM(C)T would not be limited to that produced specifically for military programmes prior to its entry into force, but the total of that amount plus the civil stocks existing at that time. In addition to this complication, the verification measures would be made much more complicated by the existence of such stocks—in effect, it could work out that identical fissile material could co-exist within a facility, some of which would be subject to inspection, some not. Under some diversion concealment strategies, the existence of such material would make it difficult to confirm the absence of diversion.

The incremental costs to verify this material would be small, and would be offset by the simplification of not having to contend with dual inventories that would complicate verification.

Element 5. Verify fissile material and facilities engaged in military applications which do not involve the production of nuclear weapons or other nuclear explosive devices:

- verify feed reserves and release stocks for naval reactors and space power reactor fuel manufacturing according to operational requirements;
- verify new fissile material production and stocks produced;
- verify exports and imports of fissile material intended for such use;
- verify the working inventory and scrap at fuel manufacturing plants;
- implement managed access for transparency of reactor fuel manufacturing; and
- verify reactor power changes to provide transparency regarding reactors installed on naval vessels.

Article 14 of INFCIRC/153 provides a mechanism for states parties to comprehensive IAEA safeguards agreements to remove specified nuclear material from safeguards for use in non-explosive military applications. There are no provisions for any transparency measures during the time that this provision might be exercised. To date, no NNWS has ever exercised this option, although a small number of states have submarine development programmes underway.[14]

Following the provisions established in INFCIRC/153, the FM(C)T would likely also make allowance for states to use fissile material for military applications that do not involve the production of nuclear weapons or other nuclear explosive devices. When the FM(C)T enters into force, the fissile material stocks set aside for military applications, and subsequent production to meet future needs, could conceal nuclear weapons production. Hence, a scheme involving the steps shown in Element 5 would limit the material available to the amounts actually required, and provide assurance that the amounts identified for this purpose are actually employed for that purpose.

The measures suggested would respect the rights of states to pursue such applications and their protection of sensitive information, while providing transparency and assurance that this provision did not provide a loophole against the fundamental intentions of the FM(C)T. Technical methods developed for IAEA verification of classified forms of weapon-origin fissile materials might find use in this application.[15]

Element 6. Verify excess military stocks:

- mandatory verification of excess military stocks having no classified properties;
- voluntary verification of excess stocks with classified characteristics (using attribute verification with information barriers); and
- mandatory proportional declarations of excess stocks in conjunction with nuclear arms reductions.

One of the most contentious aspects of past considerations of the FM(C)T has been the issue of military stocks produced before the treaty entered into force. While avoiding positions that might block such a treaty, a scheme that focuses on the verification of stocks determined by the state to be excess to *its* military requirements could provide a means to enhance the arms control benefits of the treaty.

Under a trilateral initiative between the Russian Federation, the United States and the IAEA, the technical, legal and financial issues associated with IAEA verification of weapon-origin fissile material released from military programmes in the Russian Federation and the United States were examined.[16] The FM(C)T could include provisions that would allow states to submit excess military fissile material to verification under the FM(C)T. If the provisions allowed states to submit excess fissile material with classified characteristics,[17] then far greater amounts of excess fissile material could be included much earlier in the inspection regime than if this provision only allows unclassified forms.[18]

Concluding the initial charge entrusted to the Trilateral Initiative, the IAEA, the Russian Federation and the United States agreed that the verification methods developed could be applied by the IAEA for the verification of any form of fissile material, without risk of divulging information on the design or manufacture of nuclear weapons. While additional work would be required to field the specialized verification instruments in a high security environment, the parties expressed their confidence that such a mission is practical.

Thus, incorporating the relevant provisions of the Trilateral Initiative could extend the arms control dimension of the FM(C)T while avoiding the ‘stocks’ complications cited earlier. The verification costs would be moderate, depending upon the verification performance requirements and the operations undertaken in relation to the disposition of the excess materials.

Element 7. Implement a universal system of import/export controls governing commerce in fissile materials, facilities for their production, processing and use, and specialized material and equipment, including 'dual-use' equipment.

Every state that has acquired nuclear weapons has benefited from assistance provided by other states. Sometimes the other state has provided assistance knowingly, sometimes not. The system of nuclear export controls in place today is more robust and effective than ever before. However, it is incomplete in coverage and could be made more effective without hampering prudent and legitimate peaceful applications of nuclear energy.

Commerce in specific technologies, materials and equipment could be taken under the FM(C)T as a means to create a non-discriminatory system for all parties. Such an export control regime could serve to dissuade states from engaging in nuclear activities that are not clearly appropriate for peaceful use. It could also aid in denying states access to sensitive technologies, materials or equipment that might be misused to further nuclear ambitions. Additionally, it might provide the basis for assuring the supply of fresh fuel, which would reduce the need for states to establish indigenous enrichment capabilities. It might also provide for the management of spent fuel or other radioactive wastes, which would reduce the need for states to establish indigenous reprocessing capabilities.

To affect such a control regime, the existing Nuclear Supplier Guidelines might be adopted under the FM(C)T, while taking into account the reporting requirements of INFCIRC/153 and 540.

Element 8. Implement proliferation-resistance principles and practices to aid in preventing further proliferation by guiding the development, demonstration and deployment of nuclear energy systems.

The impetus for the introduction of 'proliferation resistance' comes from renewed interest in developing a new generation of nuclear energy systems anticipating that global climate deterioration may spur an increased demand for nuclear energy in the decades ahead.[19] In particular, there are two programmes underway to develop future nuclear energy systems.

- The IAEA 44th General Conference Resolution GC(44)/RES/22 invites 'all interested Member States of the Agency to combine their efforts under the aegis of the Agency, in considering the issues of the nuclear fuel cycle, in particular by examining innovative and proliferation-resistant nuclear technology'. The IAEA's Innovative Nuclear Reactors and Fuel Cycles Programme (INPRO) was established in response to that resolution.
- Similarly, under the Generation IV Program sponsored by the United States and the associated Generation IV (GEN IV) International Forum, the issue of 'proliferation resistance and physical protection' has been a factor in the selection of candidate systems for future research and development, and is one of the specific areas to be addressed in the forthcoming viability and performance phases of the Generation IV Program.[20]

The FM(C)T Conference of States Parties might be charged with the responsibility for implementing proliferation resistance measures as a means to determine whether proposed nuclear activities are prudent and legitimate, and thus are acceptable to the world community. For example, the Conference of States Parties could:

- determine the merit of major new projects, taking into account the national energy demand, existing nuclear capability and the incremental changes that would result from the proposed project, the technical, legal and financial infrastructure, and proliferation risk;

- assure that the operation of a state's nuclear industry is consistent with proliferation-resistance, in particular, that fissile materials are not stockpiled owing to differences in demand and supply;
- monitor the conversion of research reactors fuelled with high enriched uranium to low enriched, and possibly the conversion of naval propulsion reactors to enrichments of 20% or less; and
- oversee the creation of multinational energy parks.

Element 9. Require FM(C)T Parties to adhere to the Convention for the Physical Protection of Nuclear Material (CPPNM) and implement the provisions of INFCIRC/225, and implement physical protection principles and practices in the development, demonstration and deployment of nuclear energy systems to prevent or inhibit acts of nuclear terrorism.

Additional measures to prevent or mitigate the consequences of terrorist acts could be created through the FM(C)T if appropriate provisions were to be included in the treaty. Preventing nuclear terrorism has nothing to do with stopping past military production, but it is relevant to assuring that peaceful nuclear activities carried out at the time of entry into force and in the years and decades that follow, are designed and conducted in ways that reinforce their peaceful intent.

Nuclear terrorism could involve the theft of fissile material for use in nuclear weapons or other nuclear explosive devices, the theft of hazardous radioactive materials for use in radiological dispersal devices, the sabotage of nuclear reactors or fuel cycle facilities, or the sabotage of vehicles, vessels or aircraft transporting fissile or other hazardous radioactive material.[21] The FM(C)T verification required under the elements above would necessitate the adoption of a material control and accounting system at each facility; material control and accounting systems serve as the first line of defence against certain of the scenarios for nuclear terrorism.

Material control and accounting systems serve as the first line of defence against certain of the scenarios for nuclear terrorism.

Following the framework suggested for proliferation resistance, the physical protection provisions of the FM(C)T could include a combination of *intrinsic features* and *extrinsic measures* designed to:

- minimize and control access to weapon-usable and other nuclear material, hazardous radioactive material, facilities and transport systems (e.g., through the use of personnel authorization systems, physical barriers, detection equipment, and other appropriate measures);
- minimize the vulnerability of nuclear reactor plant systems to cyber attack;
- provide immediate response, including use of force, if an act of nuclear terrorism is suspected or if unauthorized access to weapon-usable and other nuclear material, hazardous radioactive material, facilities and transport systems is anticipated or attempted;
- take immediate action to recover any stolen material and minimize the consequences of any act of nuclear terrorism; and
- protect vital equipment required to maintain radioactive materials in a safe state, in particular, for reactors the safety systems that provide reactivity control, decay heat removal, and radionuclide confinement.

The manner and extent to which the FM(C)T might incorporate provisions intended to combat nuclear terrorism would depend to some extent on the outcome of an initiative to strengthen the CPPNM. If successful, the effort underway to amend the CPPNM would extend its scope to cover nuclear material in domestic use, storage and transport, and the protection of nuclear material and facilities from sabotage. The amendment would enhance the value of the CPPNM, but it would still be limited; the amendment under consideration makes no provision for verification or peer review, it includes no requirement for mandatory application of INFCIRC/225,[22] and it does not address nuclear material and nuclear facilities in military use.[23]

Further benefits spawned by and within the regime created by the FM(C)T

The FM(C)T could be the first treaty to gain universal acceptance, as its provisions would be in the interests of all governments. The regime it would create would have a natural nexus with the NPT and other regimes, especially that of the CPPNM. The international norms created through the FM(C)T regime would strengthen the integrity of the workings of the treaties and conventions it embraces and bolster the commitments of the states parties to the respective aims and objectives. To imagine how such a regime might function, it could be useful to look briefly at three aspects of how today's regimes contribute to combating nuclear terrorism beyond the specific provisions of any existing treaty or convention.

Physical protection, the NPT and IAEA safeguards

The NPT was not written with nuclear terrorism in mind, but the regime created around the NPT has provided a context for addressing nuclear terrorism.

While the NPT itself makes no reference to 'terrorism', 'theft' and 'physical protection', the very first NPT Review Conference in 1975 called on the IAEA to further elaborate concrete physical protection recommendations, and on all states with peaceful nuclear activities to follow the IAEA recommendations and 'to enter into such international agreements and arrangements as might be necessary to ensure such protection.'[24] Interest within the NPT review process continues: for example, in the Final Document of the 2000 NPT Review Conference, 'the Conference notes the paramount importance of effective physical protection of all nuclear material, and calls upon all States to maintain the highest possible standards of security and physical protection of nuclear materials.'

Confidence-building measures

In this era of heightened threats, actions are increasingly being taken by states to improve the confidence of governments in their own national physical protection capabilities.

An increasing number of states are voluntarily participating in IAEA physical protection training activities and in peer reviews carried out under IAEA auspices.[25] The International Physical Protection Advisory Service (IPPAS) was created in 1995 to assist Member States in improving the effectiveness of their physical protection of nuclear materials and facilities. Upon request by a Member State, the Agency sends a team of specialists, who review the state's physical protection system and make recommendations for improvements not only on the technical aspects of physical protection, but also on related legal and organizational issues, and can address related needs of the requesting state, such as combating illicit trafficking. With the increased number of requests and substantial voluntary contributions, the current plan is to double the existing capability to support about six such missions per year.

Cooperative Threat Reduction

Regimes facilitate actions at various levels. In relation to nuclear issues, in particular, actions carried out under the title of 'Cooperative Threat Reduction' (CTR) are aimed at eliminating or securing weapons and materials of mass destruction that might otherwise fall into the hands of terrorists. The Material Protection Control and Accounting programme run by the United States Department of Energy is one example. It is intended to consolidate and secure nuclear materials in the Russian Federation. The basic idea behind this programme is simple: the Russian Federation and the United States, sharing the perception of a security threat arising from inadequately protected fissile materials in the Russian Federation, coordinate their efforts to secure fissile materials at specified sites.

Many analysts conclude that the CTR 'model' has been a marked success and could be successfully applied in other regions of the world,[26] that CTR could be based upon multilateral arrangements, perhaps with the involvement of international organizations and non-governmental organizations. On a limited scale, this has already been done, as in the removal of HEU from the research reactor in Belgrade, Yugoslavia, with participation of the governments of Yugoslavia,[27] the Russian Federation and the United States, as well as the IAEA and the Nuclear Threat Initiative, which provided the funding.

There is no evident reason that this kind of cooperation wouldn't work on a larger scale, and a number of possibilities are being explored. The most noteworthy is the global coalition against weapons and materials of mass destruction, which was created at the G8 Summit in June 2002.

It is difficult to imagine that CTR activities could be so extensive without the context provided by the non-proliferation regime. Such accomplishments are also highlighted at each NPT Review Conference. The FM(C)T would extend the existing non-proliferation framework allowing further CTR activities—to help states to meet their treaty obligations, or to address specific problems on which direct, concerted activities would be necessary.

Time phasing of implementation

The FM(C)T will require a significant effort and a long time to be implemented fully. The inspections will be most extensive in those states with the most extensive nuclear industries, military and civil. Ramping up to meet the requirements for full implementation will require a staff comparable to the current size of the IAEA Safeguards Department (about 250 inspectors plus support staff). Hence, it will be necessary to manage FM(C)T implementation in a manner that will not undermine the effectiveness of the non-proliferation safeguards. The priorities and planning for implementation should emphasize the fundamental objective of the FM(C)T as an instrument of nuclear disarmament—i.e., to assure that the facilities created to make fissile materials for nuclear weapons have halted production, and to assure that all excess military fissile material and all comparable civil fissile material is brought under inspection as soon as possible. As time permits, the inspection activities can branch out from there to eventually cover all such materials.

NNWS are subject to IAEA non-proliferation safeguards that are geared to detecting the acquisition of a state's first nuclear weapon. The amounts of interest, the times and the detection probabilities chosen as performance requirements for IAEA safeguards are all driven by this single consideration: timely detection of diversion of significant quantities of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons or other nuclear explosive devices or for purposes unknown, and deterrence of such diversion through the risk of early detection. Verification in states possessing nuclear weapons and in NNWS should eventually converge, however, at the outset of the FM(C)T, steps towards convergence should follow full implementation of the basic treaty elements and progress in nuclear arms reductions.

An important responsibility of the Conference of States Parties will thus be to guide, review and approve of the incremental steps leading to full implementation.

Potential impact of a nine-element FM(C)T on three communities

There are presently 191 nations in the world, of which 188 are parties to the NPT. Of these, 183 have become NNWS parties to the NPT.[28] Eight nations are not subject to comprehensive IAEA safeguards agreements, and have fissile material that is available for use in nuclear weapons. Five (France, the People's Republic of China, the Russian Federation, the United Kingdom and the United States) are nuclear-weapon states parties (NWS) to the NPT. The remaining three (India, Israel and Pakistan) have fissile material not subject to IAEA safeguards, and two of those, India and Pakistan, have tested nuclear weapons.

Table 1 illustrates the anticipated impact of the nine FM(C)T elements identified above. (It is assumed in the table that the FM(C)T would be universal.)

Financing the FM(C)T

For the goals and aspirations of the FM(C)T to become reality, adequate and reliable funding must be secured to pay for the verification activities to be carried out and for the implementation actions required in states that would not otherwise be able to meet their requirements under the treaty.

One means to finance the FM(C)T would be to follow the arrangements implemented for IAEA safeguards, including safeguards implemented in meeting the obligations defined in the NPT. The present scheme for financing IAEA safeguards stems from 1957 when the IAEA Statute was written. A budget is proposed by the IAEA Secretariat and reviewed by a Committee of the IAEA Board of Governors. The Committee recommends a budget to the Board, which then submits the budget with its recommendations to the General Conference. The Governors are often required by their respective capitals to avoid budget increases for a variety of policy and economic reasons. The current process is often driven by issues that are not connected with the safeguards mission.

One alternative that might be considered would be to finance the FM(C)T on the basis of a 1% surcharge on all nuclear-generated electricity. Today, there are 434 operating nuclear power plants worldwide and additional plants are under construction and in planning. Such an arrangement would be similar to that used to finance the Yucca Mountain Geological Repository in the United States and other existing arrangements in other states.

Applying a 1% surcharge to all nuclear electricity would produce an income in the range of one billion dollars per year. As a fixed percentage of rates charged around the world, it would increase as nuclear power applications increase, and as inflation raises the rates that customers pay. The 1% figure is expected to more than meet foreseeable needs, and is low enough so as not to impose an economic burden on the states employing nuclear energy.

With such a financing base, the FM(C)T Conference of States Parties could determine how the funding should be committed, without the conflict of limiting the verification budget to the extent that the effectiveness of the verification system is undermined. Budget excesses could provide a means to expand technical cooperation funding for worthy projects in the developing world.

Table 1. Anticipated impact of the nine FM(C)T elements

Element	Impact		
	NPT NWS	NPT NNWS	India, Israel and Pakistan
1. Past military production	Not applicable; no impact	Significant impact; extent depends upon operational status of production facilities after entry into force	
2. Declared peaceful nuclear facilities and fissile material produced for peaceful use after entry into force	None; all nuclear activities subject to IAEA safeguards	Most impact in France, United Kingdom and Russian Federation; relevance of Euratom safeguards needs to be established. The impact in the United States will depend upon the future use of plutonium fuels, e.g., as foreseen under the Generation IV Program.	Significant impact in India
3. Undeclared production of fissile material within the facilities that are submitted for inspection or in clandestine facilities	For all NNWS with Additional Protocols in force, essentially no additional impact; for other states, impact of INFCIRC/540 Protocol to comprehensive IAEA Safeguards Agreement	Significant impact with implementation of full scope INFCIRC/540 Additional Protocol. Inspection access to sensitive sites restricted according to provisions for managed access; environmental sample taking under special procedures intended to prevent divulging information on nuclear weapons design or manufacture, or other sensitive military operations	
4. Existing fissile material stocks from peaceful nuclear programmes	No additional impact foreseen; all fissile materials subject to IAEA safeguards	Significant impact in France, the Russian Federation and the United Kingdom	Significant impact in India
5. Non-explosive military applications	No impact at present; possible impact in Brazil	Significant impact in all five NWS	Possible impact in India
6. Excess military stocks	Not applicable; no impact	Significant impact in the Russian Federation and the United States initially; others later on	Significant impact later on
7. Export/import controls	No impact for states adhering to Nuclear Supplier Guidelines. In other cases, equal, moderate impact on all states exporting or importing fissile materials or relevant technologies, materials or equipment		
8. Proliferation-resistance features	Impact depends upon whether NNWS is exporting or importing	Impact on development and exports	
9. Physical protection	Equal, moderate impact on all states depending on nature and extent of nuclear operations		

Conclusion

The need for a FM(C)T is as great now as ever before; recognizing today's needs and tomorrow's opportunities could result in a treaty that would be of critical importance in maintaining the integrity of the NPT regime and enhancing security in the century ahead. The FM(C)T suggested in this paper comprises nine elements to provide a broad and substantial basis that will benefit security from the outset and lay the groundwork for future progress. The decisions on what to include in the FM(C)T are for the CD to determine; the suggestions put forward in this article are consistent with the original United Nations resolution, and are not inconsistent with the Shannon Mandate.

Consider the following:

- Current suspicions in several key countries have raised the importance of adherence to non-proliferation obligations and of international inspections to unprecedented levels. In several situations, international inspections may provide the only peaceful means to resolve heightened tensions.
- Cuba submitted its instrument of ratification for the NPT on 4 November 2002 in Moscow. Cuba's accession leaves India, Israel and Pakistan as the only states that are not parties to the NPT. All 183 NNWS parties to the NPT have undertaken not to acquire nuclear weapons, and not to assist other states or to receive such assistance. While the NPT has been remarkably successful in limiting the spread of nuclear weapons, not all parties have honoured their obligations and the future integrity of the NPT remains in question.
- States harbouring nuclear ambitions may still find assistance, sometimes with the knowledge of other states, sometimes without, involving knowledge transfers, sensitive equipment and material.
- The nuclear-weapon states parties to the NPT recognize their obligations under Article VI, but the process foreseen in Article VI has yet to commence. There are no multilateral agreements toward the elimination of nuclear weapons or restraints on the ability to manufacture nuclear weapons. Their reluctance undermines the commitments of the NNWS and denies the NPT its full influence and ability. India, Israel and Pakistan remain largely outside the community of nations on the issues of nuclear security.

Fissile materials remain essential for all nuclear weapons and controls on their production, use and export provide the principal mechanism for the international non-proliferation regime. Similar controls adopted by all states possessing nuclear weapons will provide one important means to encourage progress towards the eventual elimination of existing arsenals, and provide a basis for broader actions in the area of peace and security.

Nuclear terrorism is perhaps more likely to involve the theft of fissile materials for the manufacture of nuclear explosive devices, or the theft of hazardous radioactive materials for use in a radiation dispersal device (i.e., a 'dirty bomb'), or the sabotage of a nuclear installation or transport system with the intention of releasing radioactive material to cause harm. The casualties, property damage and economic costs associated with acts of terrorism would differ dramatically across this threat spectrum, but even a realistic hoax could have a severe impact. There are many means to address nuclear terrorism and while it is not the principal aim of the FM(C)T, it could also—directly and indirectly—reduce each of these dangers.

Incorporating the nine elements presented in this article, the FM(C)T would assume a role of critical importance in international security, setting the foundation for future arms reductions, enhancing global efforts to prevent the proliferation of nuclear weapons, and establishing a common foundation for preventing nuclear terrorism.

Notes

1 United Nations General Assembly resolution 48/75L, 16 December 1993.

2 A negotiating mandate was finally agreed on 23 March 1995 just prior to the opening of the 1995 NPT Review and Extension Conference. The 24 March 1995 report of the Special Coordinator (CD/1299), Ambassador Gerald Shannon of Canada, contained an agreed mandate that basically repeated the operative language from resolution 48/75L together with an understanding that all issues pertaining to the scope could be addressed in the context of treaty negotiation. All United Nations General Assembly resolutions on a FM(C)T since 1995 have referred to a FM(C)T negotiation in the context of the Shannon report and the mandate contained therein.

3 The Conference on Disarmament decision CD/1547 of 11 August 1998 to establish, under item 1 of its agenda entitled 'Cessation of the nuclear arms race and nuclear disarmament', an ad hoc committee to negotiate, on the basis of the report of the Special Coordinator (CD/1299) and the mandate contained therein, a non-discriminatory, multilateral and internationally and effectively verifiable treaty banning the production of fissile material for nuclear weapons or other nuclear explosive devices.

4 United Nations General Assembly resolutions 53/77 I (1998); 55/33 Y (2000); 56/24 J (2001); 57/80 (2002); no resolution was adopted during its fifty-fourth session in 1999. All of these resolutions refer to the report of the Special Coordinator (CD/1299) and the mandate contained therein.

5 *Report of Main Committee I*, 'Article VI and preambular paragraphs 8 to 12', item 10 of NPT/CONF.2000/MC.I/1.

6 From the beginning, disputes on the scope for such a treaty have divided the international community into two camps. States that believe that nuclear powers have not made a start on disarmament have maintained that such a treaty should provide a means to bring in existing military stocks, while states possessing nuclear weapons have not accepted that such a treaty (banning the production of fissile material) is the appropriate place for such steps to be taken. Those holding a broader view identify the treaty as an 'FMT', while those seeking to restrict its application refer to it as an 'FMCT', with the 'C' standing for 'cut-off' on the production of fissile material. In this article, a compromise that has been in circulation is adopted, i.e., 'FM(C)T', where the '(C)' may mean 'control', envisioning the broad scope suggested in this article, or 'cut-off', or that it may be eliminated altogether, as negotiations determine.

7 'Fissile material' in this paper is understood to include all materials suitable for use as the principal fission energy source in a nuclear weapon or any other nuclear explosive device. In that sense, 'fissile material' for the purposes of the FM(C)T should include plutonium of any isotopic composition (except for plutonium containing 80% or more of the isotope ^{238}Pu), uranium enriched to 20% or more in the isotope ^{233}U and/or ^{235}U, plus neptunium and americium. In addition, the treaty should provide a simple means to include as material subject to the treaty, any other actinide capable of sustaining a fast critical reaction that may become available in sufficient quantities in the future to warrant being added to this list.

8 If the negotiators include the actinides neptunium and americium in the definition of material that would be subject to the treaty, then that could involve minor changes. Other areas might also have a minor impact—if challenge inspections are included, for example, or if the information to be reported or disclosed would differ.

9 A question for consideration is whether the treaty should require the states to declare the amounts of fissile material produced prior to the treaty's entry into force, and if so, whether such declarations should be subject to auditing or verification. Such a measure would bear more upon disarmament than on future production, and thus one possibility might be to include such declarations in a later agreement, or this treaty could initially encourage such declarations and later make them mandatory.

10 A decision would have to be taken during the negotiations on the verification of the production reactors. If the reactors were shut down, then monitoring by satellite imagery (infra-red) should be sufficient. If the reactors remain in operation, then on-site monitoring would be needed to provide assurance that all plutonium produced is subject to inspection.

Under IAEA safeguards, termination of safeguards occurs when the IAEA determines that the nuclear material has been consumed, or diluted to the point that it is no longer useful for any nuclear activity relevant from the point of view of safeguards, or has become practicably irrecoverable.

11 The IAEA estimate of US $100 million for verification activities under an FM(C)T is based on a 1995 evaluation in which three verification options were examined. More accurate estimates of verification costs can be developed when the requirements of the treaty are fixed and consultations begin with the states possessing nuclear weapons or nuclear material not subject to a comprehensive IAEA safeguards agreement.

12 This is the 'Objective of Safeguards', taken from paragraph 28 of INFCIRC/153, *The Structure and Content of Agreements Between the Agency and States Required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons*, of June 1972, available at <http://www.iaea.org/worldatom/Documents/Infcircs/Others/inf153.shtml>.

13 Comprehensive IAEA safeguards agreements are based upon INFCIRC/153. The Additional Protocol is based upon IAEA, *Model Protocol Additional to the Agreement(s) Between State(s) and the International Atomic Energy Agency for the Application of Safeguards*, INFCIRC/540 of September 1997, available at <http://www.iaea.org/worldatom/Documents/Infcircs/1998/infcirc540corrected.pdf>.

14 Canada had a programme underway in 1987 to purchase ten to twelve nuclear submarines from the United Kingdom or France and went to the extent of exploring the exemption of the fuels under paragraph 14 of its safeguards agreement. M.F. Desjardins and T. Rauf, *Opening Pandora's Box? Nuclear-Powered Submarines and the Spread of Nuclear Weapons*, Aurora Papers 8 (June 1988), Canadian Centre for Arms Control and Disarmament.

15 Under the Trilateral Initiative, a scheme was developed that would allow the IAEA to verify any form of fissile material without revealing classified secrets related to the design or manufacture of nuclear weapons. This scheme is based upon comparing specified parameters to unclassified values. For example, the isotopic composition of weapon-origin plutonium has a ratio of the isotope ^{240}Pu to ^{239}Pu of less than 0.1. If a container of plutonium is found to hold plutonium with such a ratio, then that 'attribute' is accepted. The isotopic composition of the plutonium is measured by gamma ray spectrometry, using specialized equipment that bars inspectors from any of the measurement information other than the final ratio. The technique used to prevent such access is referred to as 'information barrier technology'. Overall, the method is know as 'attribute verification with information barriers'.

16 T. Shea, 2001, Report on the Trilateral Initiative: IAEA Verification of Weapon-Origin Fissile Material in the Russian Federation and the United States, *IAEA Bulletin*, vol. 43, no. 4, pp. 49–53, available at <http://www.iaea.or.at/worldatom/Periodicals/Bulletin/Bull434/article9.pdf>.

17 'Classified characteristics' means physical properties determined by the state in the interest of its national security to require protection against unauthorized disclosure under the laws and regulations of the state.

18 Nicholas Zarimpas (ed.), forthcoming, *Transparency in Nuclear Warheads and Materials: The Political and Technical Dimensions*, Oxford, Oxford University Press and SIPRI. See, in particular, the chapter entitled 'Potential roles for the IAEA in a warhead dismantlement and fissile materials transparency regime'.

19 Proliferation resistance impedes the diversion or undeclared production of nuclear material, or misuse of technology, by states in order to acquire nuclear weapons or other nuclear explosive devices. The degree of proliferation resistance results from a combination of *intrinsic features* and *extrinsic measures*, including, *inter alia*, technical design features, operational modalities, institutional arrangements and safeguards measures. *Intrinsic features* are intended to reduce the attractiveness for nuclear weapons programmes of nuclear material during production, use, transport, storage and disposal; prevent or inhibit the diversion of nuclear material; prevent or inhibit the undeclared production of direct-use material; and facilitate IAEA safeguards. *Extrinsic measures* include states' commitments, obligations and policies with regard to nuclear non-proliferation and disarmament; agreements between exporting and importing states that nuclear energy systems will be used only for agreed purposes and subject to agreed limitations; and commercial, legal or institutional arrangements that control access to nuclear material and nuclear energy systems (including provisions for multinational ownership of nuclear energy systems, perhaps in extra-territorial locations).

20 See *A Technology Roadmap for Generation IV Nuclear Energy Systems*, available at <http://nuclear.gov/nerac/FinalRoadmapforNERACReview.pdf>.

21 Nuclear terrorism could involve other activities that would not be immediately relevant to the FM(C)T, including the theft of nuclear weapons, strong isotopic sources used in medicine, agriculture and industry, or hazardous radioactive materials containing trace amounts of fissile material, such as high level radioactive waste. These possibilities are not addressed in this paper.

22 Guidance for physical protection of nuclear material in domestic use, storage and transport, without distinction between peaceful and military purposes, is provided in IAEA, *Recommendations for the Physical Protection of Nuclear Materials*, INFCIRC/225 Rev.4 of 1999, available at <http://www.iaea.org/worldatom/Programmes/Protection/inf225rev4/rev4_content.html>. This guidance is further expanded in IAEA-TECDOC-967 (Rev.1), *Guidance and considerations for the implementation of INFCIRC/225/Rev.4, The Physical Protection of Nuclear Material and Nuclear Facilities*, May 2000.

23 *Nuclear Security—Progress on Measures to Protect against Nuclear Terrorism*, Report by the Director General, IAEA, 12 August 2002, IAEA document GOV/INF/2002/11-GC(46)/14.

24 Chronologically, the issue first became international in 1972, when the IAEA published *Recommendations for the Physical Protection of Nuclear Material*, the revised version of which became INFCIRC 225 in 1975.

25 Note that bilateral cooperation agreements involving peaceful uses of nuclear energy often include requirements for the importing states to implement INFCIRC/225 and rights for the exporting state to inspect the facilities it provides in the importing state to determine whether or not the physical protection measures being implemented are adequate.

26 DFI International and Sparta, Inc., 2001, *The future of the Cooperative Threat Reduction Programme: Final Report*, a study for the Defense Threat Reduction Agency Systems and Concepts Office; Rose Gottemoeller with Rebecca

Longsworth, 2002, *Enhancing Nuclear Security in the Counter-Terrorism Struggle: India and Pakistan as a New Region for Cooperation,* Carnegie Endowment for International Peace, Working Paper number 29 (August)*;* Matthew Bunn, John P. Holdren and Anthony Wier, 2002, *Securing Nuclear Weapons and Materials: Seven Steps for Immediate Action,* Harvard University; Michael Krepon, 2001, *Moving from MAD to Cooperative Threat Reduction,* The Henry Stimson Center Report No. 41 (December).

27 The former Federal Republic of Yugoslavia changed its name to Serbia and Montenegro on 4 February 2003.

28 At the time of writing, the Democratic People's Republic of Korea had announced its withdrawal from the NPT. The numbers cited do not reflect the DPRK action, pending further developments.

Some reflections on transparency in the contemporary security environment

William WALKER[1]

Transparency has long been central to arms control. But what meaning does this word carry today? Has it acquired different meanings, depending on the context in which it is used and the purposes to which it is put? I wish briefly to explore the contemporary notion of transparency, and to draw attention to three forms of transparency—voluntary, non-voluntary and coercive—that are today being practised by states in pursuit of their individual and collective interests.[2] My concern is with the substantial shift in the balance of and relations between these approaches in recent years, and by the dangers that will arise if that balance and those relations are misjudged.

In the mid-1990s there was talk of constructing a transparency *regime*, especially in the context of establishing global controls over fissile nuclear materials. A radical extension of transparency was seen in many capitals as a necessary device for consolidating the gains made since the end of the Cold War and of ensuring the irreversibility of the arms reduction and disarmament measures that were then being contemplated. Such a regime would have been constituted through unilateral, bilateral and multilateral measures. Particularly important were the reforms in the safeguard system being developed under the IAEA's 93 + 2 programme, the establishment of organizations to implement the treaties banning chemical weapons and nuclear explosive testing, the expected negotiation of a Fissile Material Cut-off Treaty, and the negotiation (again expected) of a START III Treaty by the governments of the United States and the Russian Federation which would have verified the dismantlement of nuclear warheads for the first time.

No such regime has been established. Indeed, most of the transparency measures that were envisaged those few years ago have come to nought. The situation today is that transparency is even more essential to the achievement of international security, yet its attainment at an international level has become much more difficult. The means by which states are attempting to render activities transparent has also undergone a substantial change.

It is useful to distinguish three distinct if interconnected transparency processes—those that are essentially *voluntary*, *non-voluntary* and *coercive*. What do I mean by these terms? The voluntary processes are those involved in the intergovernmental practice of arms control, non-proliferation and disarmament: that is, when states volunteer information about their capabilities and activities in order to bring about mutual gains in security. Because sovereignty is involved, and because the benefits of transparency have to be weighed against those of confidentiality, this voluntary transparency has to be laboriously negotiated. There is no such thing as 'freedom of information' in this international setting: such transparency is always rule-bound, institutionalized, and held within defined limits (an obvious

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example is the NPT safeguard system as defined in INFCIRC/153). An instrument for creating trust between states, the processes by which transparency is achieved must themselves be trusted if it is to have value.

For this interstate, or *external*, transparency to function, there must also be *internal* transparency within states. States need to know, and need to establish organizational capacities so that they are in a position to know, what exactly is happening on the territories under their jurisdiction. It is no exaggeration to say that transparency begins at home. One of the important, if uncelebrated, aspects of external transparency is that it encourages internal discipline. The NPT safeguard system, with its requirement for states to establish internal systems of material accounting in line with an international best practice, can again be cited in example. Among its various benefits, a Fissile Material Cut-off Treaty would strengthen internal transparency processes in states that have not submitted their fissile materials to routine international inspection. Given the worries about weak and failed states, the importance of achieving internal transparency, and of ensuring its essential honesty, needs little emphasis.

Among its various benefits, a Fissile Material Cut-off Treaty would strengthen internal transparency processes in states that have not submitted their fissile materials to routine international inspection. Given the worries about weak and failed states, the importance of achieving internal transparency, and of ensuring its essential honesty, needs little emphasis.

Coercive transparency is the dark companion of voluntary transparency (I shall come to non-voluntary transparency below). It is being practised today in Iraq where a state is refusing to comply with the transparency obligations that it voluntarily accepted under international law. Hence the efforts by the United Nations, backed by its Security Council, to prise open the box and reveal the full extent of Iraq's WMD capabilities. Three things should be noted here. Firstly, coercive transparency is inevitably addressed to an adversary bent on concealment: it is a contest between a state's capacities to conceal and external actors' capacities to reveal, with the threat of military force the principal means by which the latter persuade the former to end its concealment. As such, a resort to coercive transparency indicates that the processes of voluntary transparency have broken down in a specific context. Secondly, coercive transparency can only be practised by great powers against comparatively weak powers, and in circumstances where the threat of force can be made real. It is inconceivable that such transparency could be imposed on the Russian Federation, or China, or India, or Japan, let alone on the United States. North Korea also demonstrates the difficulty of exercising coercive transparency where minor powers have the ability (through the threat of onslaught on South Korea in that case) to deter military action against them. Thirdly, coercive transparency is only realizable when framed by international law, and by international legal and political processes. Its legitimacy has to be established because it entails a deep penetration of national sovereignty, because it has to be accompanied by the threat of force, and because it is implemented through and by the primary international institution, the United Nations. In consequence, coercive transparency is bound to be an exceptional measure—it cannot in any sense become standard practice.

By *non-voluntary* transparency I refer to intelligence gathering, the process by which states attain information about other states or entities without their consent.[3] Faced with opponents, now including terrorist groups, which appear determined to acquire WMD capabilities and to conceal their activities, intelligence gathering becomes the first and possibly the only means by which states can begin to defend themselves. We should note that it is radically different from voluntary transparency as described above. It is subterranean, in that the means of attaining transparency are themselves covert and are given substantial immunity from the political processes of deliberation and accountability, even when intelligence agencies are cooperating amongst themselves. Almost by definition, it is not regulated and treaty-bound within the international domain, partly because it entails the persistent infringement of Westphalian norms of sovereignty, and partly because states are loath to accept any formal restriction (internal or external) on their capacities to acquire information by these means. There are certainly 'rules of the game', but they are rarely if ever formalized.

Since the mid-1990s, there has been a marked shift from reliance on voluntary to non-voluntary forms of transparency, a shift that has become much more pronounced since 11 September. The immediate post-Cold War years had seen a great extension of voluntary transparency through developments in arms control, non-proliferation and disarmament. Most states were engaged in this initiative. The trend halted after 1996–97. Following the conclusion of the treaties banning nuclear explosions (the CTBT in 1996) and reforming the NPT safeguard system (the Additional Protocol of 1997), there has been no significant development of transparency measures in the multilateral domain. What is more, the practice of building ever-increasing amounts of transparency into bilateral arms control treaties has gone into reverse. Instead of START III with its enhanced verification, the governments of the Russian Federation and the United States have concluded an arms reduction treaty in 2001 (SORT) which contains no verification measures of any kind and effectively negates those agreed in START II. Washington and Moscow may claim that verification is no longer necessary given the improvement of their relations, but the reality is that they have awarded themselves renewed freedom to deploy nuclear weapons as they see fit. They are gambling that transparency is no longer necessary for trust in their strategic relations.

Washington and Moscow may claim that verification is no longer necessary given the improvement of their relations, but the reality is that they have awarded themselves renewed freedom to deploy nuclear weapons as they see fit. They are gambling that transparency is no longer necessary for trust in their strategic relations.

In contrast, the last few years have brought a great burgeoning of non-voluntary transparency, or intelligence gathering, in the service of national and international security. The key word is *detection*—the detection of the covert activities of state and non-state actors desiring to acquire WMD and the capabilities for manufacturing them. As knowledge has diffused, as actors have become more skilled at hiding their activities, and as the United States in particular has become more anxious about being 'caught napping', the early and precise detection of clandestine weapon programmes has acquired a much higher priority. Traditional verification no longer seems capable, on its own, of delivering information in the quantity and quality that is being demanded.

These trends may be seen in some if not all capitals as justified responses to shifts in the post-Cold War security environment. They nevertheless give rise to a number of troubling questions.

Firstly, can allegiance to the NPT be sustained if the balance of expectations on transparency is skewed even more against the non-nuclear-weapon States Parties (NNWS)? Whilst the United States is turning away from multilateral arms control and is ending its commitment to transparency in bilateral arms control agreements with the Russian Federation, and whilst India, Israel and Pakistan are largely evading transparency, the NNWS are being pressed to accept a much higher level of transparency through the Additional Protocol. At the extreme, one State Party (Iraq) is currently being subjected to a process of coercive transparency that has no precedent. Although Iraq has brought this upon itself, there is a striking contrast between the medicine that is being meted out to NNWS and the freedom from intrusion that is being vigorously asserted by most of the nuclear-armed states. Can the NPT survive untarnished if it again becomes overtly hierarchical and discriminatory, and more brazenly the instrument of great power interests?

Secondly, how can the formal, internationally regulated and consensual practice of voluntary transparency be made to coexist with the greatly expanded but unregulated and nationally oriented practice of intelligence gathering? While always symbiotic with arms control in the strategic relations between East and West during the Cold War, intelligence gathering was kept at a distance from verification and safeguarding in the practice of non-proliferation policy. It has now come to the fore in this as in other fields: access to, and action in response to, intelligence has come to be regarded as a necessary part of international safeguards since the Iraqi and North Korean weapon programmes were revealed; and intelligence agencies are rightly seen as the primary sources of information on non-state actors. The developments may be unavoidable, but can we avoid institutions like the IAEA, whose efficacy depends on its integrity and reputation for impartiality, being damaged by their closer association with intelligence agencies and with the powerful American intelligence agencies in particular? How should the interfaces between the voluntary and non-voluntary systems be managed, and by whom? How can trust in the wise and effective management of that interface be secured? Is there need for some codification of the 'rules of engagement' across this interface?

Thirdly, the voluntary transparency arrangements embedded in arms control treaties involve explicit agreement on 'how much is enough'. That is, they define the quality and quantity of transparency that is required to meet security objectives. Can states any longer agree, in general or in specific cases, on 'how much is enough'? If powerful states come to believe that 'rogue actors' (state and non-state) will always be able to squirrel away materials and capabilities that can be turned to lethal effect, then the level of transparency that is required for the sustenance of confidence will tend towards infinity. When that happens, transparency loses its relevance: the only recourse is to extreme measures, including war, so as to destroy the actor that is posing the threat. Conversely, if states desirous of war deny transparency measures the opportunity to do their work, the broad processes of transparency will themselves be undermined.

It is doubtful that any actor has the capacity to conceal a sufficient nuclear capability once the spotlight is turned on it (the same may not be true of biological capabilities). That being the case, 'how much is enough' should have an answer. But in which institutions, and in which institutional processes, should responsibility be placed for providing this answer, especially if the evidence and reasoning upon which judgements need to be based are heavily influenced by intelligence agencies drawing their information from confidential sources? These questions are, of course, highly pertinent to the current debates over Iraq. Yet they are not isolated to Iraq.

Given the nature and prolixity of the threats, the pursuit of regional and global order must inevitably involve some blend of voluntary, non-voluntary and coercive transparency with much interplay between them.

Unfortunately, there are no simple answers to any of the above questions. Given the nature and prolixity of the threats, the pursuit of regional and global order must inevitably involve some blend of voluntary, non-voluntary and coercive transparency with much interplay between them. Managing this blend and this interplay will require superior statecraft and careful attention to process. A particular danger is that the voluntary system will wither away through lack of respect and attention, and could even collapse along with the treaties and agreements in which it is framed. Without the voluntary system of transparency with its roots in cooperation and reciprocal obligation, there can be little trust, and without trust states will assume the worst.

If international order is the common objective, reinforcing and extending this voluntary system, and the norms that it expresses, should therefore count among the highest priorities of states. Without it all states will become less secure—international order and civility now depend upon it. The alternative is a deep and illicit penetration of sovereignty and a perpetual reliance on the use or threatened use of force. This is not to deny the necessity of non-voluntary and coercive measures. However they will bring little security if they are not deployed against the background of a strong legal framework of arms control.

Let me conclude with some observations on transparency in the emerging hegemonic order. A hegemon with the immense resources of the United States has three possible approaches to global order. The first is to free itself from restraint and bend other states to its will through the exercise of structural power in the knowledge that no other state or group of states has the capacity to balance that power. The second approach is to exercise self-restraint: to invest heavily in international institutions, including international law and arms control, and to use all its power resources to shape and uphold these institutions. The third approach is to seek some blend of the first and second approaches, involving a careful balance of coercion and institutionalism, a balance that sustains international legitimacy.

From the mid-1990s onwards, the American administrations have moved against the second option, with the current administration veering towards the first option since 11 September. If this trend continues we are indeed in another world. My hope and expectation is, however, that the third approach will soon begin to dominate in Washington, especially if some tolerable resolution to the Iraqi and North Korean crises is achieved. If I am correct, there will be a return to cooperative institution building, including arms control and its transparency measures, within the next few years. If I am incorrect, I dread to think what the future holds.

Notes

1 Presentation given to the Seminar on International Cooperation in the Combat against Nuclear Terrorism and the Role of Nuclear Arms Control, Geneva, 18 December 2002.

2 The transparency that arises out of the processes of globalization, involving the monitoring activities of NGOs among many other things, will not be discussed here. There is no denying its importance, but I would still regard it (perhaps controversially) as secondary to the transparency practised by states, given the state's continuing primacy in global politics.

3 There have been circumstances in which intelligence gathering (usually referred to by the euphemism 'national technical means') has been allowed in arms control agreements, the Conventional Forces in Europe Treaty being perhaps the best-known example. However, they have been very much the exception rather than the rule.

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compiled by Rachel Williams

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Observations and lessons from the work of the Panel of Governmental Experts on Missiles

The following is based on what I have observed and learned from my participation in the United Nations Panel of Governmental Experts on the Issue of Missiles and all its Aspects.[1] The panel consisted of twenty-three governmental experts, meeting in three sessions over 2001 and 2002.

The panel, the first dedicated to this subject, was established by General Assembly resolution 55/33A of 31 October 2000, entitled ‘Missiles’.[2] In accordance with this resolution, the panel was convened to discuss the issues of missiles in all their aspects and to submit a report. Initially, the report was expected to recommend any measures, if agreed, to address the issue of missiles. These recommended measures could have ranged from formulating a set of principles governing national missile activities, to politically binding commitments, to possible confidence-building measures (CBMs) to reduce missile threats, or even a legally binding treaty.

Given that there currently exist no globally binding instruments on missiles, the panel could have presented a good opportunity for considering how to establish a full-fledged, legally binding treaty on missiles. However, even before the conclusion of the panel’s three sessions, it was clear that reaching agreement on a recommendation of this kind would be extremely difficult. In the end, the panel served merely as a forum for identifying and confirming the existing facts and issues arising from the possession and use of various kinds of missiles.

The panel’s work included a review of the historical origins, chronological development and actual uses of missiles as weapons systems from the First World War to the present. The panel also held discussions to confirm the existing capabilities, characteristics and various types of missiles and the driving factors in their development. The panel identified missiles as a serious threat to international peace and security. However, in the end, the panel was not able to agree on next steps, and stopped short of recommending concrete measures.

Some thoughts on why the panel could not formulate recommendations

A missile ban would be contrary to the traditionally recognized use of these weapons

First of all, unlike weapons of mass destruction (WMD), such as nuclear and biochemical weapons, missiles have been conventionally recognized as legitimate weapons systems for national defence and security.

Since the use of nuclear weapons has presented phenomenal potential for the annihilation of humankind and the use of biological and chemical weapons has been condemned by the general opinion of the civilized world, the prohibition of WMD has been universally accepted through global treaties and conventions.

Missiles, on the other hand, have been used as legitimate battlefield weapon systems since the First World War. In a sense, virtually all countries claim the sovereign right to develop and use missiles for the sake of their national defence and security. It is therefore difficult for the international community to establish a general ban or regulations on the production, acquisition, development, testing, holding or use of missiles and missile technology.

Diverse nature of missile activities, as required by various and distinctive national security interests

Virtually all states develop their national defence and acquire various missiles and missile technologies—ranging from tactical or strategic missiles to short-, medium-, intermediate- and long-range missiles—to respond to their perceived security threats.

The diverse security requirements of different states make it difficult to set uniform rules for the regulation of missile activities.

In the case of the regulation of nuclear weapons through the NPT, the international community was able to establish two clear categories to discriminate between nuclear-weapon states parties and non-nuclear-weapon states parties to the treaty. However, in the case of missiles, the process of reaching an agreement on discriminatory rules is complicated by the diverse needs and interests of each state.

Overlap between military use and peaceful applications of missile technology

The dual-use nature of certain missile technologies allows for both military and peaceful applications, making them particularly difficult to regulate and ban.

For instance, the development of long-range missiles utilizes the same technology as the development of space launch vehicles (SLVs). As many states wish to further develop and take advantage of the space applications of this technology, it becomes difficult to regulate its possession and thus the development of long-range missiles.

Experts unavoidably represent the interest of their own countries

The panel was composed of governmental experts from many countries and regions with conflicting security interests. Despite serving in their personal capacities, in practice the panellists represented the views of their own countries in the discussion.

In the course of the panel's discussion, political views and interpretations of the issues at hand were disclosed and created a stumbling block that impeded any potential agreement.

Due to the divergent views on politically sensitive and technically complex issues, such as missile defence and SLVs, the panel failed to establish a common set of objectives.

For instance, there was a reluctance to even use the word ‘proliferation’ on the grounds that it is considered judgmental by some countries. There was also debate whether the concept of ‘self-defence’ is applicable to the discussion of missile proliferation. Furthermore, fundamental disagreement arose on the category of missiles (particularly ballistic and non-ballistic) on which the panel should focus. And there was no agreement on whether the proliferation of ballistic missiles had become an overriding security issue in the field of missiles.

Prospects for future work

Under these circumstances, will it be possible in the near future for the United Nations to come up with a meaningful action programme or normative instrument to address even some of the security issues related to missiles? It seems doubtful.

As the General Assembly agreed in 2002 that there will be another United Nations panel on missiles beginning in 2004,[3] it will be important to utilize the lessons that we have learned from the first panel.

Taking into account such lessons, concrete measures we could conceivably take to address the threat stemming from missiles in the three areas of non-proliferation, arms control and disarmament, and cooperation include the following.

Non-proliferation

Given that national missile activities have been recognized as legitimate means for national defence and security, it is not feasible to ban or regulate such activities in a general manner, particularly on the demand side. But when it comes to the threat of missiles, there is an obvious danger that certain countries or non-state actors could seek excessive development or acquisition of missiles and there might be a corresponding over-supply of missiles in surplus of reasonable national defence and security needs.

As a corollary, when we look at the supply side, there must be some areas on which we can reach agreement. A typical example of this would be the activities of the Missile Technology Control Regime (MTCR) or the Wassenaar Arrangement—export control regimes designed to prevent the irresponsible transfer or over-supply of missiles and missile technology.

In going forward, the international community should build on the foundation of initiatives already in place. In this regard, future discussion on missile issues should be formulated in a way that is both complementary to and reinforcing of the existing initiatives and achievements that currently regulate missile activities.

The International Code of Conduct (ICOC, now known as the Hague Code of Conduct), initially formulated by the MTCR and now open for universality, exemplifies a best practice in this area. It is encouraging that more than ninety countries signed the ICOC at its launching conference held in the Hague on 26 November 2002.

Arms control and disarmament

In the area of arms control and disarmament we first need to encourage the further development of CBMs in the field of missiles. Because the main purpose of CBMs is to reduce the threat stemming from missiles by increasing the transparency of national missile activities, it is a relatively easy area in which to agree. Ensuring that countries are aware of each other's missile activities would contribute to the reduction of this threat, leading to greater stability.

Second, the importance of regional context should be underscored. As demonstrated by the panel's discussion, in which many of the divisions among the group stemmed from regional considerations, regional coordination should be an integral part of the development of CBMs. Despite some opinions that stressed the global application of CBMs, the prevailing view within the panel was that CBMs could not be uniformly applied due to security concerns particular to each region.

While an approach to non-proliferation could be global, arms control and disarmament in the field of missiles is best addressed in the context of regional and bilateral efforts. Two examples of this effective approach can be seen in the Pre-Launch Notification Agreement ratified by the United States and the Russian Federation and the Lahore Declaration between Pakistan and India.

Cooperation

This area concerns the ways and means to discourage any country from developing missiles, especially long-range missiles, for purposes other than space programmes.

The international community needs to further explore areas of cooperation by which incentives are provided to those states which forgo the development of missiles for military use.

In the case of dual-use technologies, such as SLVs, countries in possession of such technology should provide assistance to those countries interested in its space applications and other peaceful uses. In this way, we can use space-launching opportunities as incentives to prevent states from developing long-range missiles.

The ICOC has a few paragraphs on such incentives. But these need to be further elaborated so that they become an attractive and effective *quid pro quo*.

Conclusion

In conclusion, the fundamental question of how to deal with the issue of missiles rests with the individual country or collective actions of so-called missile clubs, such as the MTCR. Beyond that, I am confident that the ICOC will be the most effective tool for curbing the proliferation of missiles and missile technology, for some time to come.

Ambassador LEE Ho Jin

Deputy Permanent Representative of the Republic of Korea to the United Nations

Notes

1 *The issue of missiles in all its aspects: Report of the Secretary General*, General Assembly document A/57/229 of 23 July 2002, available at <http://disarmament.un.org/wmd/missiles.htm>.

2 Available at <http://disarmament.un.org/wmd/missiles.htm>.

3 United Nations General Assembly resolution 57/71, available at <http://disarmament.un.org/wmd/missiles.htm>.

UNIDIR FOCUS

What Prospects for Missile Controls?

Following its role as consultant to the 2001–2002 United Nations Panel of Governmental Experts on Missiles, UNIDIR, jointly with the Institut français des relations internationales (IFRI), held the seminar 'What Prospects for Missile Controls?' in Paris on 20–21 March 2003.

The meeting provided an opportunity for informal, off-the-record discussion of the challenges posed by the spread and qualitative improvement of missile capabilities. Arms control approaches to the missile issue, as well as the content and prospects of current and future initiatives, were also considered.

Meeting participants discussed missile-related security issues in the context of regional and global trends in technology transfers, missile proliferation, testing and deployment. Regional and global threat perceptions were also examined. The meeting took a practical and hands-on approach to looking at which types of missiles could be subjected to arms control regimes (ballistic or cruise missiles, conventional or WMD-armed missiles) as well as the issue of dual use. In this regard, the seminar analysed specifically the link between missile defences and missiles control regimes. Participants reviewed current proposals and approaches to missile controls (MTCR, ICOC, the Russian proposal and that of the United Nations Panel of Governmental Experts), their impact and the possible avenues for further action.

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The Scope and Implications of a Tracing Mechanism for Small Arms and Light Weapons

Effective tracing of all small arms and light weapons (SALW) requires adequate marking and record-keeping, along with international cooperation that enables relevant authorities to trace the sources, supply routes and diversion points of illicit weapons in a timely and reliable manner.

Most SALW are marked during manufacture. However, marking practices vary widely from country to country. Such divergences hamper the identification of weapons recovered outside their country of manufacture. In addition, the adequate marking of individual SALW needs to be supported by adequate record-keeping if it is to serve a useful purpose. The extent to which records are accessible, the length of time they are held, and their accuracy are key issues in this regard.

Tracing typically transpires in relation to two types of contexts, each of which presents special challenges. Most commonly, tracing is carried out for law enforcement purposes. In such cases, tracing needs to be effected in a reliable and timely manner. Here, access to computerized records, some degree of centralization, and the gathering and sharing of data extrinsic to the weapon itself (i.e. recovery location, possessor, etc.), are essential.

Tracing may also be carried out to investigate, prevent or disrupt losses of SALW from military and other official stocks as well as their illicit trafficking. Tracing for these purposes involves particular complexities including longer, more complex weapons supply lines, and the involvement of customs services, military police and intelligence services. Here, national military marking and record-keeping, along with access to an accurate reading of these, are particularly important.

Produced jointly by UNIDIR and the Small Arms Survey, *The Scope and Implications of a Tracing Mechanism for Small Arms and Light Weapons* examines the different aspects of SALW tracing and marking practices and international legal instruments currently in place. The volume argues that existing marking, record-keeping and tracing cooperation need to be substantially improved in order to facilitate more effective tracing. An international instrument building on existing norms and standards, including those contained in regional agreements, could play an important role in this regard.

The Scope and Implications of a Tracing Mechanism for Small Arms and Light Weapons
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UNIDIR, 2003
238 p
UN sales number GV.E.03.0.7
US$ 20 (plus shipping and handling)