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CIVILIAN NUCLEAR FACILITIES AS WEAPONS FOR AN ENEMY:

A submission to the
House of Commons Defence Committee
by
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1. Introduction

On 18 December 2001, the House of Commons Defence Committee published a report, The Threat from Terrorism. In the accompanying press notice, the Committee announced that it will continue its work on the threat from terrorism, and indicated that written submissions are welcome. Accordingly, the Institute for Resource and Security Studies (IRSS) offers this submission. The submission was prepared by Gordon Thompson, executive director of IRSS. Dr Thompson was based in the UK during the period 1969-1979 and has subsequently performed a number of studies on UK-related issues.

This submission addresses the potential role of civilian nuclear facilities as radiological weapons for an enemy of the UK. That enemy might be a foreign state, a foreign or domestic group of terrorists, or a malicious or insane individual.

A thorough analysis of the subject addressed by this submission would require a book-length document, which would cite a large body of technical literature. This submission does not purport to provide a thorough analysis. Instead, it touches on a few points and mentions a few pieces of literature. Its purpose is to bring a neglected subject to the Committee's attention. The Committee is welcome to contact IRSS if there is a desire to pursue the subject in greater depth.

2. Relevant Nuclear Facilities

A civilian nuclear facility is a potential radiological weapon if the facility contains a large amount of radioactive material that can be released to the environment. Three types of facility are prominent in this respect, namely: (a) commercial nuclear reactors; (b) nuclear fuel reprocessing plants; and (c) radioactive waste storage facilities. In the UK, there are facilities in each of these three categories. Similar facilities exist in France and other countries, many of them at locations such that a release of radioactive material from the facility could have significant impacts in the UK.

Experience shows that nuclear facilities can release significant amounts of radioactive material to the environment. Prominent examples are the Windscale reactor fire of 1957, the Kyshtym radioactive waste storage tank explosion of 1957, and the Chernobyl reactor explosion and fire of 1986. Studies show that civilian facilities now operating could release large amounts of radioactive material as a result of influences that include human error, equipment failure, natural forces (e.g., earthquake), and acts of malice or insanity.

A notable example of a potential radiological weapon for an enemy of the UK is the B215 facility at Sellafield. This facility houses 21 steel tanks and associated equipment in above-ground concrete cells. The tanks contain high-level radioactive waste (HLW) in the form of a self-heating, acidic liquid that requires continuous cooling and agitation. This liquid HLW is a product of nuclear fuel reprocessing at Sellafield. At present, the tanks contain about 1,550 cubic metres of liquid HLW. The radioactive isotopes in this liquid include about 8 million TBq (2,400 kilograms) of caesium-137. For comparison, the 1986 Chernobyl reactor accident released to the atmosphere about 90,000 TBq (27 kilograms) of caesium-137, representing 40 percent of the inventory of caesium-137 in the reactor core. Most of the offsite radiation exposure from the Chernobyl accident can be attributed to caesium-137, which has a half-life of 30 years.

3. Using a Nuclear Facility as a Weapon

In order to use a nuclear facility as a radiological weapon, an enemy must obtain a release of radioactive material from the facility. A variety of methods are available for this purpose. Each facility has its particular vulnerabilities, which are apparent to knowledgeable persons. If the enemy has an agent in place inside the facility, the obtaining of a release might not require violent action. In the absence of an inside agent, the obtaining of a release would generally require violent action.

One potential method for obtaining a release through violent action would be to arrange for the impact of a fuel-laden commercial aircraft on the facility. For example, the aircraft might be a Boeing 747-400, which has a maximum takeoff weight of 360-400 tonnes and a fuel capacity of 200-220 thousand litres. Complete combustion of 100,000 litres of jet fuel -- about half the fuel capacity of a Boeing 747-400 -- will yield energy equivalent to that from exploding 900 tonnes of TNT, although with lower efficiency in converting combustion energy into blast. Thus, the impact of a fuel-laden Boeing 747-400 on a nuclear facility would unleash large forces, potentially causing a significant release of radioactive material.

By way of illustration, consider the impact of a fuel-laden commercial aircraft on the B215 facility at Sellafield. According to press reports, more than 200 commercial flights pass within 50 miles of Sellafield each day. The UK Nuclear Installations Inspectorate (NII) stated in 1995 that the impact of a large commercial aircraft on the B215 facility could breach one of the concrete cells surrounding a liquid HLW tank, and the tank itself, leading to a release of HLW to the environment. NII did not consider the effects of the accompanying fuel-air explosion. Nor did NII consider the implications of this event for cooling and containment of the liquid HLW in the other tanks in the B215 facility.

The initial breaching of one or more liquid HLW tanks, and the accompanying fuel-air explosion and fire, would create severe radioactive contamination of the Sellafield site. The resulting radiation fields could preclude actions needed to provide cooling and containment of liquid HLW in other tanks in the B215 facility. Then, over a period of days, these tanks would boil dry, after which the solid residue in the tanks would heat up and release volatile radio-isotopes -- including caesium-137 -- to the atmosphere. The eventual release of caesium-137 to the atmosphere might exceed 50 percent of the inventory in the tanks. The present inventory (see Section 2, above) is about 8 million TBq (2,400 kilograms). Thus, the release of caesium-137 to the atmosphere might exceed 4 million TBq (1,200 kilograms).

The preceding discussion shows how an enemy could use one event -- in this instance, an aircraft impact -- to trigger other events that yield a more significant outcome. This amplifying effect is illustrated by the fire-induced collapse of the World Trade Center buildings in New York on 11 September 2001. It is likely that a sophisticated enemy would seek an amplifying effect in a future attack. For example, an enemy possessing a crude nuclear weapon would probably consider using this weapon on a civilian nuclear facility, in order to amplify the weapon's radiological impact. Detonation of a fission weapon will create about 7 TBq of caesium-137 per kilotonne of yield, and a crude weapon could have a yield in the 10-kilotonne range. The resulting fallout of about 70 TBq of caesium-137 would be greatly amplified if the weapon were used on the B215 facility at Sellafield, which houses liquid HLW containing 8 million TBq of caesium-137.

4. Effects of a Radioactive Release

Radioactive material could be released from a nuclear facility in two ways: (a) as an atmospheric release composed of small particles and gases; or (b) as a liquid release. An atmospheric release would create a plume that would travel downwind. Particles in the plume would be deposited on the ground and other surfaces. A liquid release would contaminate ground water or surface water. For example, a liquid release at Sellafield could contaminate the Irish Sea.

As an illustration of the implications of a large release, consider a release to the atmosphere of 4 million TBq (1,200 kilograms) of caesium-137. This release would represent 50 percent of the present caesium-137 inventory in the B215 facility at Sellafield. The implications of such a release can be illustrated by the area of land that would become uninhabitable due to contamination by caesium-137.

In this submission, the threshold of uninhabitability of land is assumed to be a whole-body, groundshine-radiation dose of 100 mSv over 30 years, representing about a three-fold increase above the natural background level of radiation. A person residing at the boundary of the uninhabitable zone would receive a radiation dose of 100 mSv over the first 30 years. Thereafter, the dose rate at this location would decline, due to radioactive decay and weathering of the caesium-137. A person choosing to live within the uninhabitable zone would experience a higher dose rate, potentially orders of magnitude higher in the most heavily contaminated locations. Contamination of food and water supplies, or the deposition of radio-isotopes other than caesium-137, could cause additional radiation doses, both within and outside the uninhabitable zone.

In typical weather conditions, an atmospheric release of 4 million TBq of caesium-137 would, if the radioactive plume travelled over land rather than the ocean, render uninhabitable about 200,000 square kilometres of land. The use of a little imagination shows that this event would be a disaster of historic proportions, with health, environmental, economic, social and political dimensions.

As an indication of the significance of our assumed threshold of uninhabitability, note that a radiation dose of 100 mSv over 30 years corresponds to an average dose rate of 3.3 mSv per year. The health effects of radiation exposure at this dose level have been estimated by the US National Research Council (National Research Council, 1990). According to these estimates, a continuous lifetime exposure of 3.3 mSv per year would increase the incidence of fatal cancers in an exposed population by about 8 percent for males and 11 percent for females. About one person in five normally dies of cancer. In other words, in a population residing continuously at the boundary of the uninhabitable zone -- thereby receiving a whole-body, groundshine-radiation dose of 3.3 mSv per year -- about 2 percent of people would suffer a premature death due to a fatal cancer that would not otherwise occur. Ingestion of contaminated food and water, if this occurred, would expose members of the population to internal radiation, thereby causing additional cancer fatalities.

5. Present Understanding of the Threat

The UK government and the nuclear industry have been warned on numerous occasions that civilian nuclear facilities are tempting targets for enemy action. A Royal Commission discussed this threat in a 1976 report (Flowers et al, 1976). The author of this submission, Gordon Thompson, has made many attempts to alert government to the threat. For example, in June 1998, at a briefing held within the Parliament buildings, the author presented a report which addresses, among other matters, the potential for an enemy-induced release of radioactive material from Sellafield's B215 facility (Thompson, 1998).

The consistent response of government and industry to these warnings has been to ignore or rebuff them. Documents and statements that have emanated from government and industry provide no indication that either entity has ever attempted a thorough analysis of the threat or the options for reducing the threat. Analyses of this kind may have been attempted in secrecy. However, the author doubts that any thorough analysis has been performed by industry or government.

6. Addressing the Threat

The threat posed by civilian nuclear facilities should be addressed in the UK's defence strategy. These facilities are potential weapons with strategic implications. Yet, defence planners lack a thorough understanding of the threat and the options for reducing the threat. This deficiency should be corrected at the earliest opportunity. A two-step process of technical analysis is required.

The first step would be to perform a thorough analysis of the nature of the threat. This analysis would assess the vulnerability of each relevant nuclear facility to potential enemy actions, and the consequences of the releases of radioactive material that could be caused by those actions.

The second step would be to identify, for each significant facility, a range of options for reducing the probability or magnitude of a release of radioactive material from the facility due to enemy action. Among these options would be measures for active or passive defence of the facility. Other options would include measures for reducing the inventory of radioactive material at the facility.

A substantial part of the threat arises from the reprocessing of spent nuclear fuel at Sellafield and La Hague. Large amounts of radioactive material are concentrated at these sites, much of it in readily-mobilisable forms. At Sellafield, liquid HLW stored in the B215 facility could be mobilised as described in Section 3, above. At La Hague, spent nuclear fuel is stored in water-filled pools in a high-density configuration; loss of water from these pools could cause the fuel to burn, thereby releasing radioactive material to the atmosphere.

In view of the substantial threat arising from reprocessing, special attention should be given to the merit of continuing this activity. If reprocessing lacks merit, then it should be stopped immediately. At Sellafield, the stopping of reprocessing would prevent the further production of liquid HLW, and would expedite the rundown of the liquid HLW inventory through vitrification. At La Hague, the stopping of reprocessing would remove the rationale for accumulating spent fuel at this site in high-density pools. At both sites, the stopping of reprocessing would allow resources to be redirected to enhancing the robustness and safety of facilities for managing radioactive material.

Numerous analysts have determined that reprocessing lacks merit from the perspectives of economics, radioactive waste management, and international security. For example, the Royal Society has concluded that the assumptions underlying the UK's reprocessing programme "no longer obtain" (Royal Society, 1998). Moreover, reprocessing separates plutonium from spent fuel, thereby increasing the world's inventory of weapon-ready fissile material. The Royal Society and many other observers have expressed concern that separated plutonium might be used by hostile states or terrorist groups to make nuclear weapons. Although plutonium inventories at Sellafield and La Hague are comparatively secure, reprocessing at these sites provides legitimacy for the accumulation of plutonium at less-secure locations. Thus, reprocessing poses a double threat. It provides enemies with pre-deployed radiological weapons, while helping enemies to gain access to nuclear weapons.

A high-level group advising the US government has examined the security of nuclear weapons and fissile material in Russia, concluding (Baker, Cutler et al, 2001):

> "The most urgent unmet national security threat to the United States today is the danger that weapons of mass destruction or weapons-usable material in Russia could be stolen and sold to terrorists or hostile nation states and used against American troops abroad or citizens at home. This threat is a clear and present danger to the international community as well as to American lives and liberties."

This warning was directed to the US government, but is equally applicable to the UK. In view of the potential for an enemy to amplify the impact of a crude nuclear weapon by using it on a civilian nuclear facility, the UK defence strategy should assign a high priority to improving the security of nuclear weapons and fissile material in Russia and around the world. Moreover, the UK policy on nuclear fuel reprocessing and plutonium management should be compatible with the UK defence strategy.

7. Recommendations to the Commons Defence Committee

IRSS recommends that the Defence Committee assign a high priority to informing itself about the threat posed by civilian nuclear facilities. The Committee should not rely upon the government or the nuclear industry to provide the relevant information. Experience shows that these entities are reluctant to address the threat, and cannot be trusted to provide a thorough analysis of the threat and the options for reducing the threat. The Committee should take direct responsibility for obtaining this information.

The Committee should call upon the Parliamentary Office of Science and Technology (POST) to conduct a thorough, independent analysis of the threat and the threat-reducing options, using the two-step approach outlined in Section 6, above. To perform the analysis, POST should assemble an expert group with members from inside and outside the UK, and should sponsor specialist studies as necessary. Employees of the government and the nuclear industry could serve on the expert group, but should be personally accountable for their input.

POST should be tasked with providing the Committee with an interim report in 6 months and a final report in 12 months. These reports should be presented to the Committee at hearings where government, industry, academia and citizen groups are also able to make presentations. After these hearings, the Committee would be in a position to formulate its own recommendations for future action.

The subject to be addressed in the proposed POST analysis and the proposed hearings is central to the future security of the UK. In the UK, the traditional approach to addressing this subject would be to do so in secrecy. However, experience shows that a climate of secrecy will stifle the development of the information that the Committee needs in order to do its duty. Accordingly, the analysis and the hearings should eschew secrecy, with some limited exceptions. The exceptions would cover detailed technical information that could be useful to an enemy.

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