Asia-Pacific Review, Vol. 12, No. 2, 2005

Weapons of Mass Destruction (WMD) in the Twenty-first Century

RYUKICHI IMAI

In 1945 two bombs in Hiroshima and Nagasaki shook the world as something whose explosive power was some 200,000 times a one thousand ton TNT bomb. The extent of damage has been extensively discussed. An exchange of a megaton-range strategic bomb could wipe out the earth and its civilization. It is possible that with the passage of time, the analysis of WMD war has become intellectually less real. It is time to carefully study a possible WMD world war in the 2030s.

The accuracy of targeting and observation, and the extent of destruction of enemy objective(s) from high or low flying Weapons of Mass Destruction (WMD), large or small, are well kept military secrets. Sixty years ago the cases of Hiroshima and Nagasaki showed vivid examples of the use of crude nuclear weapons, and in 2001, the 9.11 attack on the World Trade Center Building in New York did the same for massive ordinary explosives. While attacks with ordinary explosives have since occurred in London, Egypt, and Madrid, fortunately those of a nuclear scale have not taken place since World War II. Currently, no live data exists regarding either large megaton devices (such as the Bikini test in 1954) or Novaya Semuliya where Khrushchev tried and failed to test a 100-megaton hydrogen bomb or larger in 1962. Much talked about massive urban or field chemical or biological warfare in the 2003 Iraq War did not happen, and fortunately the 1995 Aum Shinrikyo Tokyo subway attack with the nerve agent sarin was not repeated. Nevertheless, the world remains threatened.

Meanwhile, computer simulation of a one megaton (one million tons TNT equivalent) hydrogen bomb attack at lunchtime in mid summer on the corner of 42nd street and 7th Avenue in Manhattan proved, in addition to the direct explosion, heat and radiation damage to people and buildings, associated problems of surface, air, water and underground transportation and emergency rescue. Further, the unavailability of electricity, water, gas and other utility services and the inability of various facilities to provide medical and other emergency help would effect unrecoverable damage to

ISSN 1343-9006 print; 1469-2937 online/05/020092–12
Routledge Journals, Taylor and Francis <http//www.tandf.co.uk/>

DOI: 10.1080/13439000500394139

the entire New York City and cause it to stop functioning as a modern city. Some people have even argued that due to such extensive damage, the only option would be to burn the affected area by Napalm fire to avoid spread of deadly contamination.

The approximately 20-kiloton atomic bombs Little Boy and Fat Man almost completely destroyed the middle-sized cities of Hiroshima and Nagasaki, each claiming close to two hundred thousand lives (exact details are not known). Having recovered, the two modern cities today can no longer reveal what Hiroshima and Nagasaki looked like in the summer of 1945, but what remains in the NHK film library (as well as pictures of Tokyo after the March 10, 1945 fire bombing and others) gives accurate description of the world's largest destruction by fire bomb. If the 9.11 New York Trade Center terrorism represented an explosion of four hundred thousand pounds equivalent of TNT (about one hundredth the scale of Hiroshima or Nagasaki), larger scale nuclear, chemical or biological attacks such as those described in horror fiction would bring far more massive and literally unrecoverable damage to human society.

There are two main approaches to building nuclear explosives from enhanced neutron chain reactions of fissile material such as uranium and plutonium. Uranium metal enriched in U-235 (fissile) isotopes from its natural 0.7 percent to something over 90 percent can be divided into two 10-kilogram halves, placed in a gun-barrel type device, joined together with very high speed and large force by massive TNT explosions on both ends into one very small mean radius high density metal core. Doing this creates a very short mean free path for enormous number of neutrons for fissioning heavy atoms and produces a TNT multi-kiloton equivalent explosion. The same can be achieved by taking about a 10-kilogram ball of Plutonium-239 metal (not naturally available but produced in reactors by U-238 absorbing excess neutrons). Plutonium spheres are surrounded by a TNT explosive blanket and implosioned (as opposed to explosion) or compressed into the spherical center. Some documents mention that these implosions will compress a 6-cm radius plutonium sphere into 0.4-cm radius and produce bombs with a destructive capability of one hundred kilotons. The basic (unclassified) principles of nuclear weapons were published by the US Army Environmental Center (USAEC), then the Atomic Energy Commission, as the Smyth Report in October 1945, immediately after the first bombs. This was published mainly for the purpose of justifying the two-billion-dollar expenditure on the Manhattan Project. (It is worthwhile remembering that in the 1940s a 25-cent silver quarter could buy a juicy hamburger, and two billion dollars represented an enormous purchasing power). Numbers used in the above description were chosen by the Standing Advisory Group on Safeguards Implementation (SAGSI) for International Atomic Energy Agency (IAEA) safeguards criteria. Half a dozen members of the international committee (on which the author was a member representing Japan) oversaw IAEA Safeguards Implementation. Numbers quoted here are general round numbers and not exact specifications. Hydrogen bombs are a mixture of different isotopes of hydrogen (hydrogen, deutrium, tritium and lithium) contained in natural or depleted uranium shell, with the atomic bomb placed at the center. First the atomic bomb is exploded, and the large amount of energy fuse hydrogen isotopes enter the high temperature plasma and create very large-scale explosion. Single H-bombs are capable of generating 300 kilotons to 50 megatons of heat.

Since 1945, New Mexico (and the South Pacific, and Siberia) test sites produced a very large number of nuclear weapons as can be seen from inventories of bombs ranging from less than ten in 1940s to tens of thousands in the 1980s. It was only after the November 1985 Reagan/Gorbachev Geneva Summit Joint Declaration that an agreement was reached "that nuclear wars can never be won and must not be fought" and both sides turned from "not increasing nukes" to "actually reducing" the arsenal, for which 1987 INF elimination of short- to medium-range land based accurate missiles was the real beginning of the reduction process. At the time, Japanese top leadership was quite unaware of the superpowers' accurate medium missile competition in Europe. The US and Russia agreed in the year 2002 to reduce to the level of a total of 1,700 to 2,200 strategic and targettable warheads each by the year 2012, a total of less than one tenth of earlier reduction target including spare, reserve, even including small scale, arterially shells and tactical, suitcase size. These bombs must have been considered excessively superfluous and unnecessary. One does not have to

Table 1 Nuclear weapons around the world, 1945 to 2002

	US	Russia	UK	France	China	Total
1945	6					6
1946	11					11
1947	32					32
1948	110					110
1949	235	1				236
1950	369	5				374
1951	640	25				665
1952	1,005	50				1,055
1953	1,436	120	1			1,557
1954	2,063	150	5			2,218
1955	3,057	200	10			3,267
1956	4,618	426	15			5,059
1957	6,444	660	20			7,124
1958	9,822	869	22			10,713
1959	15,468	1,060	25			16,553
1960	20,434	1,605	30			22,069

(*continued*)

Table 1 *Continued*

	US	Russia	UK	France	China	Total
1961	24,111	2,471	50			22,632
1962	27,297	3,222	205			30,824
1963	29,249	4,238	280			33,767
1964	30,751	5,221	310	4	1	36,287
1965	31,642	6,129	310	32	5	38,118
1966	31,700	7,089	270	36	20	39,115
1967	30,893	8,339	270	36	25	39,563
1968	28,884	9,399	280	36	35	38,634
1969	26,910	10,538	308	36	50	37,842
1970	26,119	11,643	280	36	75	38,153
1971	26,365	13,092	220	45	100	39,822
1972	27,296	14,478	220	70	130	42,194
1973	28,335	15,915	275	116	150	44,791
1974	28,170	17,385	325	145	170	46,195
1975	27,052	19,055	350	188	185	46,830
1976	25,956	21,205	350	212	190	47,913
1977	25,099	23,044	350	228	200	48,920
1978	24,243	25,393	350	235	220	50,441
1979	24,107	27,935	350	235	235	52,862
1980	23,764	30,062	350	250	280	54,706
1981	23,031	32,049	350	274	330	56,034
1982	22,937	33,952	335	274	360	57,858
1983	23,154	35,804	320	279	380	59,937
1984	23,228	37,431	270	280	415	61,624
1985	23,135	39,187	300	360	425	63,417
1986	23,254	40,723	300	355	425	65,057
1987	23,490	38,859	300	420	416	63,484
1988	23,077	37,333	300	410	430	61,550
1989	22,174	35,805	300	410	435	59,124
1990	21,211	33,417	300	505	430	55,863
1991	18,306	28,595	300	540	435	48,176
1992	13,731	25,155	300	540	435	40,161
1993	11,536	22,101	300	525	435	34,897
1994	11,012	18,399	250	510	400	39,571
1995	10,593	14,978	300	500	400	27,131
1996	10,886	12,085	300	450	400	24,121
1997	10,829	11,264	260	450	400	22,203
1998	10,763	10,764	260	450	400	22,637
1999	10,698	10,451	185	450	400	22,184
2000	10,615	10,201	185	470	400	21,187
2001	10,492	9,126	200	350	400	20,567
2002	10,600	8,600	200	350	400	20,150

open an antiquated SIOP book to recognize that more than sufficient weapons are available. The close to a total of hundred of thousands nuclear weapons held by the US and USSR together would have been enough to destroy the planet earth many times over and bring about Rachel Carson's "Silent Spring" in which no sound of approaching spring could be heard throughout the earth.

Partly as a means to deal with excessive hydrogen bombs that the two countries had built up, and at the same time to promote the cause of peaceful use of nuclear energy in the era of the 1970/80 oil shock, both the US and USSR started the "Peaceful Nuclear Explosion Project (PNE)" in the 1970s. Both countries encouraged that millions of tons of excess hydrogen bombs be used for exploring underground oil and gas resources, or using them for building canals to divert water flow for irrigation and transportation, including a second Panama Canal and Malay peninsular waterways bypassing the narrow, unprotected Malacca Straight. The author was once invited by the USAEC to attend the new Peaceful Nuclear Explosions (PNE) natural gas exploration project in New Mexico. Remotely comparing signals from each other's underground nuclear testing gave the US enough reason to believe that Moscow was using the PNE in Siberia in fairly large scale, something that was later admitted. In other words, both the US and USSR could analyze each other's underground nuclear testing from a distance in scientific detail, and this is one of the reasons that the Comprehensive Test Ban Treaty (CTBT) cannot yet be ratified. Specifically, this is because very small new design atomic bombs also have to be underground tested. The US project to produce fusion of tritium and diutrium pellets in the Lawrence Livermore Laboratory by using a high energy laser had not yet reported success of the experiment. If it did, it could be a violation of the CTBT treaty.

On the other hand, the level of investment in modern nuclear, electronic, high accuracy based and sophisticated weapons added to the financial burden of armaments while supersonic bombers, very large scale (for instance Trident D-5) submarines and further expansion of nuclear devices into outer space (Star Wars, for example) placed large scale financial burdens on both countries.

Figures for the annual US military expenditure of some three hundred billion dollars and over, or 5.5 percent of the GNP were discussed by sources such as the International Institute for Strategic Studies (IISS) or Stockholm International Peace Research Institute (SIPRI, of whose Governing Board I was once a member), but figures for the USSR were difficult to determine and budget numbers from various sources never agreed. For instance, the cost of maintaining soldiers or nuclear arms in the Warsaw Pact were not calculated the same way as in NATO. It was known that Warsaw Pact calculations under-emphasized the actual cost, which was said to come from Soviet inventory-taking methods. It was also known, for instance during the 1970s and 1980s, that both Washington and Moscow were complaining that nuclear-related expenditures far outdistanced the actual military benefit of defense (or offense) needs, and that both would like to reduce the expenditure and place the peace dividends on social and industrial reconstruction. Strobe Talbott, then of *Time* magazine in Washington DC, vividly described the feeling on both sides of the Atlantic Ocean as being such that the prestige and defense confidence alone would not allow either side to defend less than the opponent. In the process, it was agreed that the Soviet Union was building and deploying about the same scale of nuclear weapons, missiles, submarines, etc. as the US and must be spending about the same amount of actual budget as the US, (except for the yet unknown cost of Star Wars) which in the case of the USSR meant about 15 to 20 percent of the GNP. It was said that this level of military expenditure over ten to fifteen years would cause great disorder to the national economy, and thus the Soviet Union must be near bankrupt. (Other such examples are said to be Israel and the Democratic People's Republic of Korea, DPRK.)

In 1985 when Mr. Gorbachev took over the Kremlin, he discovered the bankruptcy. With a similar feeling, Mr. Reagan agreed to the *New York Times* editorial call for the "Peace Dividend" in late 1989. The nuclear build-up would be reduced and the peace dividend, which could have totaled half the nominal defense budget, should be spent on restructuring and rebuilding sound and basic social infrastructure. Then follows the series of real reduction of nuclear weapons through the START talks. Finally in the year 2002, two pages of Strategic Offensive Reduction (SOR) Talks, instead of several hundred pages of previous arms control agreements including detailed description of arms to be eliminated and space-based national technical means of verification, simply bluntly stated the target strategic arms reduction level. As has been pointed out earlier, the "actual reduction of nuclear arms" started only with 1987 INF treaty while the earlier agreements were very thick and detailed legal and technical documents to limit nuclear weapons increase to not more than certain agreed-upon levels. That the INF treaty was concluded and ended up in the 2002 SOR meant victory for US negotiation. This can be judged by the fact that limiting the number at 1,700 to 2,200 left spares and repairs as additional while eliminating sophisticated details of national technical means of verification, which used to occupy many pages of detailed treaty description and appendices, and their interpretation. That the limiting numbers gave larger room for US Trident D-5 submarines and Minuteman ICBM compared with Russian land-based very large ICBMs is clear proof that these phases of nuclear disarmament finished in a US victory. This left the excess Soviet nuclear weapons, especially, not satisfactorily attended, and the US and Russia have established a "cooperative threat reduction program" to work together in solving problems of "stray nuclear arms or their components."

The picture today seems that the East/West nuclear arms control talks concluded for the first time since the 1945 UN Baruch Plan through Cuba (1962) and NPT (1970), SALT I (1972) and SALT II (1979), SS-20 NATO Double Decision leading to INF (1987), START I (1991), and START II (1993), START III (2007) and SOR (2002). After so many decades, after so many famous negotiators' detailed work, and after so may pages of draft, redraft, memoir and side letters for technical verification signed but not ratified, a more-or-less victory on the side of the US could be said to have come about. However, on the other hand, one may say that a situation in which strategic nuclear exchange is almost unthinkable and not useful has arrived; therefore whether the US or Soviets won the arms race is not worth proving either way.

Neither East nor West are any longer seriously looking for a day that strategic nuclear weapons would attack one of its cities or industrial centers or military bases. Such an attack would bring unrecoverable and almost meaningless damage and destruction. Swift retaliation in kind is of no interest or comfort. What people are concerned about is that the alliance pledge of swift retaliation in kind would certainly stop the onset of initial strike, and except for minor nuclear countries, nobody is interested in initiating the deadly game. By the time the first nuclear strike is launched on the ocean or on desert (or underground or outer-space tested in some threatening manner), neither side would be serious to select urban target(s) as a reply.

This leaves a terrorist attack by rogue state(s) using small scale WMDs whose likely range is above the 9.11 size but under the Hiroshima scale. This is the only explosive range not tested in reality in terms of nuclear, conventional or other WMD attack(s). It is based on the assumption that such a state's first WMD would be a small and crude device not larger than Hiroshima or Nagasaki at the maximum. In other words, only the threat of use of small scale (but larger than terrorist) would be meaningful. Japan and Germany insisted on the right of peaceful nuclear technology in the 1970s and obtained compromise. Iran and DPRK are saying the same thing today, but sixty years after use of the initial WMD.

If 9.11 type terrorism represents some sort of line that separates terrorism and WMDs, something that exceeds that level of destruction is likely to be a nuclear explosion with Uranium 235 or Plutonium 239, which are less efficient than the ones described above that are more or less optimum.

If one can produce highly enriched uranium, he would try to produce enrichment above 90 percent U235, be it through centrifuge (which today is the most likely technology) or magnetic (which may be too bulky). The 1981 Israel attack of Iraq's Osirak research reactor was more likely a misunderstanding of Begin about fissile material because the Osirak reactor was a highly enriched experimental device, and if sufficient amount is available, it should be able to provide a genuine WMD. One other method is to extract plutonium from spent (irradiated) fuel from a research or power producing reactor. It is known that India used its heavy water research reactor to extract Pu239 isotope rich plutonium for its bomb. Pakistan is known for basing centrifuge technology of Almero, URENCO. When I was personally shown Almero and Windscale centrifuge plants more than twenty years ago, the sound emitted and the scale of the German, Dutch, and UK centrifuge plants did not seem to be of mass production scale. One much-talked about technology is whether DPRK extract(ed) Pu 239 from the Nyongbyon reactor or KEDO PWR, which is a million kilowatt scale pressurized light water cooled and moderated electricity generating reactor. Both enrichment and natural uranium irradiation in research or prototype reactors provide technical opportunities to divert (sometimes with considerable difficulties) possible weapons grade material.

As an engineer I have run into hypothetical possibilities of diverting uranium or plutonium and designing crude nuclear weapon(s). When working on a uranium centrifuge machine my friends and I drew up a design of connecting different level centrifuge piping to produce, unnoticed by inspectors, a small amount of highly enriched material in a production plant intended for three percent or so material. It is not too difficult to arrange such piping, while it is difficult for an IAEA inspector to find. (One might add that the original IAEA safeguard under NPT was designed by half a dozen international safeguards scientists and adopted by IAEA conference to serve NPT purposes.) Another technique is to extract a small amount of plutonium 239 from working graphite (Calder Hall type or Nyongbyon type reactor). Early in the reactor operation one extracts a limited amount of natural uranium fuel from various spots in the reactor core then dissolves a small portion and analyzes the plutonium produced. The purpose of this operation is to check if the neutron distribution according to thermal-hydro distribution calculations matches the reality of neutron distribution. The actual neutron distribution can be read from plutonium conversion of uranium. The plutonium found by IAEA inspectors early in the reactor life were probably the results of this calculation check operation. The total amount of plutonium involved through this operation is very small. Since I was in charge of nuclear fuel for the 150 MWe Improved Calder Hall reactor in Tokaimura, I cannot say that such an idea never crossed my mind.

Later in fuel life, when natural uranium was burned to 5,000 or 6,000 MWD/Te the major problem is whether plutonium with less than 60 or 70 percent of Pu239 can explode under the TNT based spherical compression as described earlier. If it can, then irradiated fuel from a light water reactor with burn up of 35,000 to 50,000 MWD/Te can supply weapons material. This issue of water-reactor fuel has been a long-term debate about which USAEC or UKAEA did not express any view during the early phase of Atoms for Peace campaign. For sometime plutonium was not considered serious near-future fuel for peaceful purposes, other than in the case of a fast breeder reactor much later in the technology calendar. To borrow enriched uranium from USAEC for running light water reactors, etc. was sufficiently complicated and weapons-related. When I was first involved in purchasing an advanced Calder Hall reactor from the UK, spent fuel extracted from a reactor at about 3000 or 4000 MWD/Te burn-up was to be returned to the UK with a re-purchasing price better when Pu239 contents were of a higher ratio, which was sufficiently telling of the market evaluation of plutonium. Extraction of plutonium was the reason why Pakistan and the Republic of Korea were prevented by the US from natural uranium spent fuel reprocessing at home (both French design plants). Japan was also involved in trouble with the US Carter Administration regarding Tokaimura reprocessing plant operation (also French design). I was selected in the rounds of negotiating with the State Department representative Professor Joseph Nye and spent a number of weeks in Washington and Tokyo in 1977 regarding the value and right of plutonium recycling, including the Fast Breeder Project. I was chosen to do this job because a couple of years earlier when Joseph Nye came to Japan to explore the plutonium "misuse" possibilities, I was the only Japanese willing and capable of discussing the subject. I was given an honorary title and attended meetings with Mr. Nye's team. I was also a member of a small Japanese delegation to write an IAEA inspection manual (under NPT), spending more than a year in Vienna to work out IAEA Safeguards details under NPT. This was one of the reasons why I was asked to later join the Foreign Service as an ambassador to Geneva, Kuwait and Mexico (the latter are two oil producing countries). When I resigned from the Japan Atomic Power Co. (as a chief engineer) and moved to the Foreign Service I was the only PhD in Engineering in the service. It is useful to note that peaceful use of nuclear energy in 1965 was something that came to include some undefined military use in later years, especially after Israel, India, and DPRK. Terrorism has almost glorified the rogue states.

My strong arguing point with Mr. Nye was that immediately after the 1970s oil shock, use of self bred plutonium was a matter of energy security and is a matter more important than the Middle East oil. That Japan ratified the NPT in 1976 was associated with a strong statement that the right for peaceful use of nuclear power should in no way be jeopardized, which the US Government, along with other nuclear weapons power solemnly pledged to honor. Nuclear reactors were important export items in the near future. For that purpose freedom to produce enriched uranium and plutonium fuel was very important future strategy. The agreement was reached and continues today that Japan is free to reprocess spent reactor fuel, as long as she does not extract plutonium as a single metal, but always as a mixture of uranium and plutonium. It is a technique that bypasses NPT limitations on plutonium use as a single metallic element and it is difficult to understand why the US and Iran cannot work out a similar solution today if Iran is willing to reveal details of plutonium extraction plant since reparation of U and Pu is the most difficult process. It is possible that the supplier of Pu plant design may have been unwilling to touch the delicate line. Or one might say that by 1977, Japan was extremely lucky to have found U/Pu mixture extraction as not violating the right of peaceful use of nuclear power.

At one time, I was asked to conduct literature and document a survey about explosive capabilities of light water reactor fuel. The US AEC had conducted explosive tests of water reactor grade plutonium and succeeded in explosion. The Los Alamos National Laboratory had sent a scientist to Washington DC to convince me of this and other explosion related properties of plutonium. I was not. It turned out that the "water reactor grade plutonium" in question was gas-cooled Calder Hall fuel of about several hundred MWD/Te burn up, while the exact burn up of the metallic fuel was not revealed in detail. With regard to water reactor plutonium properties, I looked through considerable amount of US source documents through the internet, and several US based Pu study commissions kindly included me in their discussion. Studies headed by Professor Glenn Seaborg, Harold Agnew, William Panovsky, John Holdren, Richard Garwin and others led to without failure statement of a "personal assurance that reactor grade plutonium explodes, but due to the Atomic Energy Law no technical details can be discussed or evidence can be provided."

The document most widely quoted in these discussion was by Carson Mark: "Explosive Properties of Reactor Grade Plutonium" Science and Global Security 1993, vol. 4, pp 111–128 (Director, Theoretical; Division, Los Alamos National Laboratory, 1947–1972).

The literature is mainly discussion of explosive ratio of the world's first Pu weapon as tested in New Mexico, with various strength neutron sources inserted, while detailed mathematics and calculations were not provided. Carson Mark commented that figures were more or less taken as calculational by Oppenheimer's "back end of the envelope type" results without providing details or assumptions. The Kuruchatov Laboratory was said to have copied the US Fat Man design as provided by Los Alamos scientist Klaus Fuchs. That US and Russian laboratories had exactly the same model of the Fat Man on display means both the US and USSR were technically neutral regarding the weapons design.

I have no real access to the 30,000 or 40,000 MWD/Te water reactor plutonium's capability to explode in the Fat Man configuration. The Fat Man diagram is not clear as to electricity source, neutron source and other details and certainly not meant to help understand the details of the device. As I have no detailed training in nuclear science except for one year at USAEC's Argonne National Laboratory near Chicago, where Enrico Fermi built the world first nuclear reactor, CP-1, I had no access to the weapon's real configuration or heat treatment of plutonium metal. If the weapon's design is as easy as the Fat Man documents seem to convince us, it is difficult to determine why DPRK or any other country had not underground tested the first device yet.

One of the possible explanations is the well known gap between detailed design diagrams and manufacturing drawing with detailed know how including real curve, temperature control and other knowledge only a direct human hand contact can convey. When importing advanced foreign technology, which Japan experienced so many times after the Korean War, it is always difficult to describe the gap between very detailed design with all the written specifications, and indescribable manufacturing know how which only successful manufacturing experience can transmit. My experience was when building the most modern Pressurized Water Reactor for electricity generation, we built a scale model of the plant and rechecked the design over and again, and this was indeed useful. What one reads from detailed design and what one can feel by touching the actual machines and tools are not exactly the same. If nuclear weapon design can be simply reproduced from papers it is difficult to see why a country like DPRK with much experience of exporting missiles and other weapons cannot yet explode a bomb. Maybe it is that the drawing paper of weapons design left misleading minor details of information from place to place. In discussing with US, German, Swiss scientists on this point and at IAEA, I have on a number of occasions felt that we shared the same doubt. It is understandable that many countries felt that immediately after importing light-water reactors would be national nuclear power stations.

It would seem that with the change in fuel supply, be it for electricity generation, heating, or transportation, the first thirty years of the twenty-first century will probably have to give an answer to this plutonium problem. In other words, the age of nuclear fuel and especially plutonium fuel was not around the corner, because plutonium is a difficult and complicated material. If making a Pu bomb is easy and can be easily worked out, it is possible that DPRK and Pakistan could not manufacture the configuration or could make but not explode it. Nor were the COCOM-like export controls sufficiently detailed or timely to prevent technically capable and willing manufacturers.

Under different circumstances, it is a difficult decision to explode this "uncertain bomb" due to all sorts of technical, political and other implications of the "nuclear bomb with question marks." One can get the sense of such difficulties from the USAEC description of what renewal and other operations are considered to restructure the bomb again. On the other hand, with details of weapon technology advancing, test explosion is not the only possible means for this difficult technology requiring a step up from detailed design study to "really getting the feel of it." There are a number of scientists who think that this is the case.

It took the first ten to twenty years before the question was seriously raised to the world whether water reactor plutonium can be turned into explosives.

(That two million kw electricity generating reactors at KEDO could have been accommodated in the DPRK power grid is another problem which will solve itself if North and South electricity grids can be tied up.) Since DPRK or Iran water reactor issues are discussed mainly in the political domain by diplomatic experts, it may still take some time before details as to the role of WMD in this category are clarified.

About the author

Ryukichi Imai served as Ambassador of Japan to Kuwait and Ambassador of Japan to Mexico. He has been active in disarmament issues since 1980 and prior to joining the Institute for International Policy Studies he was the Permanent Representative of Japan to the Conference on Disarmament in Geneva. Dr. Imai joined IIPS as a distinguished research fellow in 1991 and currently serves as Research Counsellor. His publications in Japanese include “Science and Nation” (Chuokoron 1967), “Science and Diplomacy” (Chuokoron 1994), and Nuclear Non-Proliferation and IAEA Safeguards (Nikkan Kogyo 1994). He received an MS in Mathematics and a Dr. Eng. in Nuclear Engineering from the University of Tokyo, and MA degrees from Harvard Graduate School and the Fletcher School of Law and Diplomacy. In 1999 he was awarded The Order of the Sacred Treasures, Gold and Silver Star by the Japanese government for his work.