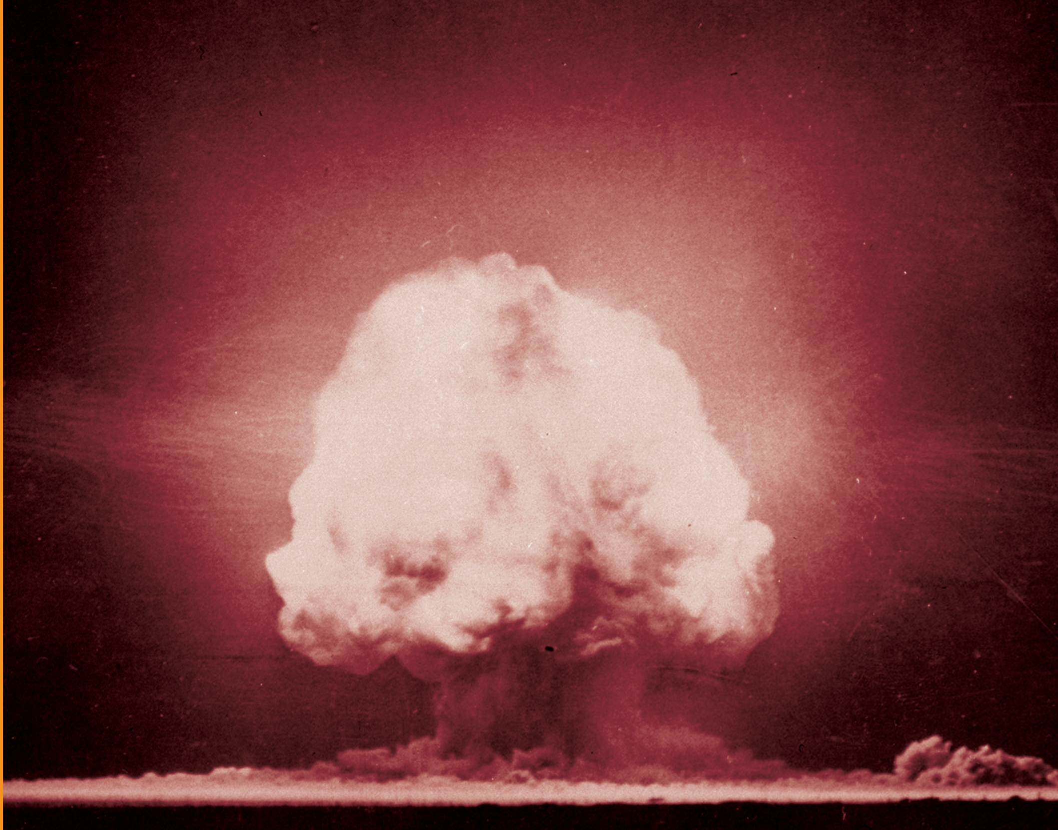
THE NUCLEAR GENIE

Prof. M.N. Sastri D.Sc., Ph.D., F.N.A.Sc.



Centre for Policy Studies
Gayatri Vidya Parishad
Visakhapatnam

2014

CENTRE FOR POLICY STUDIES was launched on October 2, 1995, the 126th birth anniversary of Mahatma Gandhi, with the object of providing a forum for the intellectual, the academic and the expert to interact, focusing on issues and policies of contemporary relevance. The Centre regularly organises meetings and seminars on policies and issues relating to areas of politics, society and development and brings out a bimonthly bulletin carrying articles on different themes and subjects.

Publications of CPS :

A Study on Street Children in Visakhapatnam, brought out by the Centre was released by Dr. Abid Hussain, former Ambassador, in December 1996. Emancipation Before Empowerment — A Study of Women's Problems in Visakhapatnam, another publication of the Centre, was released by Shri P.V. Narasimha Rao, former Prime Minister, in August, 1999. A booklet on Values in Higher Education by former Vice Chancellor Dr. B. Sarveswara Rao and Education and Technology — Challenges of a Paradigm by Dr. RVR Chandrasekhara Rao also a former Vice Chancellor was released by APSCHE Chairman Prof. K.C. Reddy in November, 2004. A Book on the Impact of Electronic Media on Women, Visakhapatnam : A Case Study, was released on May 10, 2005 by Shri C.S.Rao, IAS., Chairman, Insurance Regulatory and Development Authority of India. At the request of Visakhapatnam Municipal Corporation CPS has also submitted a report on Feedback on Subhram and Jana Chaitanya authored by Dr. Mrs. P.V.L.Ramana and Dr. Mrs. S.Rajani.

On October 2, 2005 when CPS completed ten years, the following volumes were released:

Decennial Volume, a collection of CPS Bulletin articles, Footprints of Divinity, A Gandhi Reader, Reflections on Religion and Philosophy by Shri Challa Sivasankaram. The Profligate Civilisation - Essays on Energy and Environment by Prof. M.N. Sastri was released in 2007. Education, Development and Culture - Essays in honour of Sri Vavilala Seetaramaiah was released on June 26, 2009.

At the fifteenth anniversary function of CPS on October 6, 2010, the following books were released:

Dialogue and Democracy - Reflections on Ideas, Issues and Policies (CPS Bulletin Editorials), Footprints of Divinity, A Gandhi Reader (2nd Edition), Heritage and Culture of India, by Shri Challa Sivasankaram

World Demographic Trends - by Prof. M.N. Sastri was released on August 4, 2011.

Dr M.M.Pallam Raju, Union Minister released on June 29,2012 Dialogue and Democracy- Reflections on Ideas, Issues and Policies (2nd in the series), an anthology of twenty two articles.

Over 225 meetings and seminars have been organised by CPS since its inception. Among the eminent persons who addressed CPS are : Shri P.V. Narasimha Rao, former Prime Minister, Dr. Abid Hussain former Ambassador to USA, Shri Soli J. Sorabjee, former Attorney General of India, Shri T.R. Prasad, IAS, former Cabinet Secretary, Dr. Amrik Singh renowned educationist, Shri Khushwant Singh, author and journalist, Shri K. Jayachandra Reddy, former Chairman, Press Council of India, Shri Vavilala Gopalakrishnayya, Shri N. Ram, Editor-in-Chief, The Hindu, Cmde C. Uday Bhaskar, former Director NMF and IDSA Sri B. Satyanarayana Reddy, Ex-Governor, Shri Surendra Mohan, Ex-M.P., Dr. E.A.S. Sarma Shri T.S. Krishna Murthy, , former Chief Election Commissioner Shri K.P.Fabian former Ambassador and Vice Admirals Raman Puri, R.P. Suthan and Anup Singh and Dr M.M. Pallam Raju, Union Minister for HRD.

The first issue of the bimonthly Bulletin of Centre for Policy studies was released on Gandhi Jayanti in 1996, on the occasion of the first anniversary of Centre for Policy Studies. The Hundredth Bulletin was released on April 16, 2013 by Cmde. C.Uday Bhaskar, former Director NMF and IDSA, Delhi.

All publications of Centre for Policy Studies are distributed free of cost.

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First Edition : 2014

Copies can be had of : DIRECTOR
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47-7-23, Ba-Bapu Bhavan
Dwarakanagar, 4th Lane,
Visakhapatnam - 530 016.
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Printers : **Sathyam Offset Imprints**
49-28-5, Madhuranagar,
Visakhapatnam - 530 016
Tel : 0891-2735878

a token of grateful appreciation...

Nuclear Energy- Friend or Foe? was Prof. M.N. Sastri's first article published in the fifth issue of the Bulletin of Centre for Policy Studies on June 2, 1997 .Since then he has been regularly contributing articles to the bimonthly Bulletin. *On the Brink of a Nuclear War*, the latest and fourteenth in the present series of articles titled *Nuclear Genie,* is carried in the August 2,2014 issue, the 108th Bulletin. The fourteen articles published in the series and the two that will follow, sixteen in all, are now being brought out in a book form and released on his 90th birthday, on August,5, at a function in Andhra University where he had studied and taught before retiring as Professor and Head of the Department of Chemistry. His previous work *World Demographic Trends* published in 2011 was a compilation of twenty of his articles carried in the Bulletin, like the twenty nine of his essays on energy and environment that had been brought out in the book titled *The Profligate Civilisation* in 2007.

The Nuclear Genie is Prof. Sastri's third work Centre for Policy Studies is privileged to bring out.From the first chapter *The Genie out of the Bottle* to the last *The Genie with Janus Face* Prof. Sastri's sixteen articles are packed with information, incisive analysis and some thought – provoking comments. Robert Oppenheimer, with his keen interest in Sanskrit literature, chose the name *Trinity* (after Brahma, Vishnu and Shiva) for the first atomic explosion conducted under his supervision on July 16, 1945. Such was the intensity of the explosion that an astonished Oppenheimer quoted from the Bhagavat Gita: "There floated in my mind, a line from Bhagavat Gita in which Lord Krishna is trying to persuade the Prince (Arjuna) that he should do his duty: I am become death, the shatterer of worlds."

The nuclear arms race between the two super powers, proliferation of nuclear weapons, the entry of China and other countries, overtly and covertly, into the club of nuclear weapon states and the serious threats posed by huge stockpiles of nuclear weapons are elaborately dealt with by the author. Writes Prof Sastri " It is estimated that at the peak of the cold war, the explosive power of the nuclear arsenals of the two nuclear super powers was of the order of 13,000 megatons (equivalent to a million Hiroshima bombs). This has a potential to destroy life on the planet several times over. A typical thermonuclear warhead has an explosive yield of two megatons. When detonated, about 90 per cent of this energy is released in less than one millionth of a second causing massive destruction over an area 45 kilometres across. This energy is equal to the explosive power of all conventional weapons employed in the entire six year period of World War II (1939-45), the most destructive war ever fought!" One is reminded of the well known science writer Arthur Clarke's comment when his attention was drawn to Bertrand Russell's oft-quoted warning that if there were to be a third world war the fourth would be fought with bows and arrows. "Russell was an optimist" quipped Clarke!

Prof Sastri draws attention to the generation of electricity by commercial reactors in some advanced countries. There are "439 nuclear reactors in 31 countries, providing about 16% of the world's electricity. The US produces the most, with nuclear power providing 20.2% of its electricity in 2009. France produces the highest percentage (75.2%) of its power needs from nuclear reactors. The European Union as a whole gets 30% of its electricity from nuclear energy. In India these reactors numbering 21 have a total power output of 5780 MWe contributing about 3.5 per cent of the country's total power generation.....Whether we like it or not there is presently no alternative to nuclear power to meet the country's fast rising energy needs,"writes Prof.Sastri. He concludes on a note of caution: "Nuclear Genie is seen both as a destroyer of life and a potential energy provider. The fate of the world hinges on how diligently the society bridles this Genie and guides it on the path of energy security."

We cannot thank Prof. Sastri adequately but I am sure all the members of the governing body of the Centre for Policy Studies and Gayatri Vidya Parishad join me in conveying our grateful thanks to this doyen among teachers and researchers for his support to the Centre for Policy Studies, right from its inception. The streams of scholarly contributions that flow from his prolific pen enhance the quality of the bimonthly Bulletin. Prof. Sastri has always been a source of strength to us in our modest endeavours. I thank my former colleague Prof. Mrs B. Meena Rao for the proof reading she has patiently done. It is my fervent hope that this book of Prof. Sastri will be received with the same warmth and interest as his earlier works.

Centre for Policy Studies
Visakhapatnam.
August 5, 2014

A. Prasanna Kumar
Director

Preface

It was exactly hundred years ago that H.G.Wells in his book

"The *World set free*" predicted that the uranium atoms would split, yielding huge energy, which would replace the steam engine in electricity generation. He also predicted the development of atom bombs with a synthetic element "which could devastate everything for miles." These predictions, made at a time when very little was known about the nuclear phenomena, became a reality through pathbreaking investigations culminating in the construction in December, 1942 of a nuclear reactor for energy generation and synthesis of the element plutonium used in the first ever detonation of an atom bomb by the US on July 15, 1945. With these two events the world has inherited the grave consequences of nuclear weaponisation as well as the possibility of meeting the fast growing global energy demand. In these articles I have attempted to briefly narrate these developments. I am extremely grateful to Prof. A. Prasanna Kumar, Director, Centre for Policy Studies for his support and encouragement in this endeavour.

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M.N. Sastri

Contents

The Genie Out of the Bottle

"A discovery is said to be an accident meeting a prepared mind" observed Nobel Laureate A. Szent Gyorgi (1893-1986), the discoverer of Vitamin C. The phenomenon of radioactivity exhibited by uranium and thorium is an example of an accidental discovery by Antoine Becquerel in 1896. This was followed by many vital discoveries that had far reaching implications. These include

Discovery of new radioactive element radium and polonium by Madame Curie

Identification of energetic alpha, beta and gamma radiations from radioactive elements (1899)

Nuclear disintegration theory of Rutherford and Soddy (1902)

Discovery of isotopes (1909)

The structure of atom proposed by Rutherford and refined by Bohr (1913)

Artificial transmutation of elements by Rutherford (1917)

Discovery of the neutron by Chadwick (1932)

Discovery of artificial radioactivity by the Joliot-Curie couple (1933)

Discovery of the fission of uranium nucleus by neutrons by Hahn and Strassmann (1938)

Prediction and confirmation of release of large energy release in fission by Frisch And Meitner (1939)

Prediction by Bohr that fission was due to the isotope of uranium with mass 235 which is present at a concentration of 0.72% in natural uranium-238

While the world knew very little about these ongoing investigations, the radioactive decay of elements like uranium, thorium and radium attracted the attention of H.G. Wells, considered as the "Father of Science Fiction". He concluded that while the rate of energy release in radioactive transformation is small, the total amount of energy released is huge. Using this logic Wells in his monumental book "The World Set Free" published in 1914, predicted that the uranium atoms would eventually split, yielding huge energy, which could replace the steam engine in electricity generation. He forecast the operation of a commercial nuclear power plant in 1953. He even predicted that the scientists would construct "atom bombs" from an artificial radioactive element, which he called Casolinium, and that when these atom bombs are dropped on cities by warplanes they become raging volcanoes that devastate everything for miles. Interestingly the pioneers in nuclear studies ruled out such a possibility. Rutherford observed, "Anyone who expects a source of power from transformation of these atoms is talking moonshine." Albert Einstein compared particle bombardment to "shooting in the dark at rare birds." Bohr felt that the chances of taming the atomic energy are remote.

Leo Szilard, a Hungarian scientist who fled to England in 1933 to escape the Nazi regime, was inspired by Well's prediction. He hypothesized that if a nuclear reaction produced neutrons, which cause further nuclear reactions, the transformation might be self-perpetuating releasing energy. He however did not foresee fission as the mechanism for his chain reaction, since fission was not discovered or even suspected at that time. He filed a patent for his ideas of a simple nuclear reactor the following year. After fission was discovered in 1938, Szilard who by then moved to the US, joined Enrico Fermi, an Italian scientist who fled Italy. Working at Columbia University they experimentally established on March 5, 1939 that neutron multiplication through a chain reaction in uranium fission was indeed possible. Szilard realized that, as predicted by Wells, it is also possible to use atomic energy to produce bombs. Apprehending that Germany under Hitler could be already pursuing the assembly of the atomic bomb, he felt that the Allies should forestall Germany in this task. He along with fellow émigré scientists Edward Teller and Eugene Wigner approached Albert Einstein to address a letter to the US President F. D. Roosevelt. In this letter dated August 2, 1939 drafted by Szilard, Einstein explained the possibility of assembling extremely powerful bombs of a new type and one such bomb "might very well destroy the whole port together with some of the surrounding territory." Einstein in his letter also expressed his apprehension that that Germany may be pursuing the assembly of an atom bomb. This was based on the information that Germany has taken over the uranium mines and initiated a programme in this direction at the Kaiser Wilhelm Institute, Berlin. President Roosevelt constituted a committee for examining the issue. But there was no overall "sense of urgency" among its members. Only an amount of $6,000 was provided to Fermi and Szilard to carry out their investigations at Columbia University! With good progress in the studies relating to nuclear chain reaction and exchange of information between American and British scientists the dream of unlocking and using the energy stored in uranium seemed closer to becoming a reality. With the bombing of Pearl Harbour in December 1941 and Japan, Germany declaring war on the US, and the fear that Germany might make atomic bomb for use against the Allied countries put the US on alert. Scientists who migrated to US moved to Chicago to work on the project. On the morning of December 2, 1942 the world's nuclear pile liberating energy from uranium fission through a chain reaction, marked the birth of the nuclear era.

Meanwhile, early in 1942, a team of scientists led by Glen T. Seaborg working at the University of California, Berkeley isolated a new element by bombarding uranium with neutrons. The reaction involved the transformation of the abundant isotope uranium with mass 238. Named plutonium (the element Casolniun hypothesized by Wells), this element was shown to be capable of undergoing fission chain reaction with several advantages including easier manipulation compared to uranium-235.

Things began to move fast after Pearl Harbour, leading to the starting of the Manhattan Project in the US with General Leslie Groves of the US Army as its head. Groves had a reputation "as a doer, driver and a stickler for duty.' He knew how to give orders and how to make people work.

The first problem was the acquisition of uranium required for the project. The St. Joachimstahl source in Czechoslovakia was not available as it came under German control. The Colorado mine in US did not have sufficient supply. The only source available was the Shinkolobwe mine in Belgian Congo operated by the Union Minière du Haut Katanga under permission from Belgium. Edgar Sengier, its resourceful director, having got an inkling of the potential of the mineral, managed to transport by sea about 1,200 tons of the mineral to US and store it in Staten Island, New York. Groves acquired the entire stock. Other uranium supply sources were the US Colorado and the Canadian Great Bear Lake mines.

There was also a windfall of uranium for the project. In April 1945 a German U-boat-234 set sail to Japan with valuable military cargo. This cargo, among other materials contained about 1,200 pounds of uranium usable for bomb assembly by Japan. With the defeat of Germany, the commander of the U-boat surrendered on May 12 to the commander of the US ship USS Sutton. Under great secrecy the uranium cargo was reportedly delivered to the Manhattan Project. The 7.7 pound uranium-235 content of this uranium haul is believed to have become part of the uranium that went into the bomb that destroyed the city of Hiroshima. Ironically Japan received the uranium in a form that was not intended.

Work began in three super secret atomic cities- Oak Ridge in Tennessee for preparation of enriched uranium-235, Hanford in Washington State for production of plutonium from nuclear reactors and Los Alamos in New Mexico for the design and testing of the bomb. By 1945 the project had nearly forty laboratories employing nearly 200,000 people. The scientists drawn from several countries included 20 Nobel Laureates. The programme cost US$ 2 billion ($25 billion present day). Robert Oppenheimer was appointed Director of the Los Alamos unit.

By early 1945, uranium-235 from Oak Ridge and plutonium from Hanford were available in quantities required for the assembly of the bomb. An important requirement was that before detonation, the fissile material in bomb should not assume a size as large as the critical mass. This is because the stray neutrons present in the fissile material will initiate a rapid reaction in the body of the fissile material which could end up in a premature or fizzy explosion.. For this reason the fissile material must be brought into explosion–ready supercritical mass in an extremely short time (a fraction of a mini second) before detonation. Two methods were used, both involving the use of specially made high explosives. These were the gun method and the implosion method. The gun method, which was found feasible for assembling the uranium device, was impractical for plutonium. An implosion device had therefore to be adopted for plutonium. It was further decided to conduct a full-fledged test of the implosion type weapon for establishing its feasibility.

The Alamogordo Test Range in New Mexico was chosen for conducting the test which was named the Trinity test. The name Trinity was believed to have been chosen by Oppenheimer, who had an avid interest Sanskrit literature, with reference to the Hindu divine Trinity Brahma, Vishnu and Shiva. At 5:29:45 AM on July 16, 1945 the first ever nuclear explosion woke the world. William L. Laurence, the sole official journalist covering the event wrote in the New York Times dated August 26, 1945," And just at the instant there arose as if from the bowels of the earth, a light not of this world, the light of many suns in one. It was the sunrise such as the world has never seen, a great super sun climbing in a fraction of a second to a height of more than 8,000 feet, rising ever higher until it touched, lighting up earth and sky all around with dazzling luminosity. Up it went, a great wall of fire, a mile in diameter, changing colours from deep purple to orange, expanding, growing bigger, rising as it was expanding, an elemental force freed from its bonds after being chained for billions of years." The explosion made a hole in the desert half a mile across and melted the sand, which on hardening covered the hole with a sheet of glass.

Oppenheimer rued, "There floated in my mind, a line from Bhagavat Gita in which Lord Krishna Is trying to persuade the Prince (Arjuna) that he should do his duty: I am become death, the shatterer of worlds." (11.32)

General Groves in his report said," I no longer consider the Pentagon a safe shelter from such a bomb."

The 15,000 ton TNT yield of the bomb astounded even the scientists who designed and assembled the bomb.

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Destruction of Hiroshima and Nagasaki

There were several important developments just before the Trinity test. With the surrender of Germany and Italy the war in Europe ended in May 1945. President Roosevelt died in April 1945 and Vice President Harry S. Truman succeeded him as the US President. In the general elections held in the UK, Winston Churchill, who led the country to victory, was defeated and was succeeded by C. R. Attlee as the Prime Minister. The Manhattan Project was kept a closely guarded secret by Roosevelt with information shared only with Churchill. Truman came to know about the project only hours after being sworn in as the President. Even the Soviet Union, a close ally in the war effort, was kept in the dark. It was only during the Potsdam Conference during a conversation with Stalin on July 24, 1945 that Truman mentioned about the successful detonation of the first atom bomb on July 16.

After assuming office, President Truman set up an Interim Committee on Atomic Energy under the chairmanship of Henry L. Stimson, Secretary of War, to discuss policy matters regarding the use of nuclear weapons in the combat and the possible political implications such a use might have. As Secretary of War, Stimson had control of the Manhattan Project with direct supervision over General Groves. After witnessing the destructive potential of the atom bomb, the scientists working at the Chicago unit of Manhattan Project began worrying about the military takeover of the weapon for use against Japanese civilian population. Arthur H. Compton the group leader constituted a committee under James Franck, with members that included Szilard, Seaborg and Rabinowitch to highlight the danger of the use of the bomb. The report, signed by several prominent nuclear scientists, recommended to the Interim Committee that the atom bomb be not used as a weapon to force the surrender of Japan. About 150 scientists working at the Manhattan Project in a petition drafted by Leo Szilard also asked President Truman to consider an observed demonstration of the atom bomb before using it against civilian population. As Szilard circulated his petition, General Groves, who harboured an intense dislike of Szilard, not only sought ways to take action against him, but even saw to it that the petition never reached Truman! The bureaucracy and the top military brass presented to Truman forceful arguments for using the bomb. They said that the bomb would avenge the Pearl Harbor attack.

Developed with a huge budget the bomb must be used to demonstrate the technological prowess of the US. With the Japanese forces determined to fight to the end with sheer doggedness and no surrender forthcoming (though this was not true), the use of the bomb would save an American invasion risking a large number of American lives. On the diplomatic front the bomb can be used as a powerful 'big stick' to counter the Soviet Union, which was already asserting itself in several contentious issues in the wake of Germany's surrender.

Though he had reservations, Stimson went with the Committee which in its report to the President advised that a nuclear weapon be used without warning as soon as possible against a military target in Japan. The cities of Hiroshima and Kyoto were among the targets identified. But Stimson got Kyoto deleted because of his attachment to the city as a cultural centre and which he knew from his honeymoon trip!

At 8-15 hrs on August 6, 1945 the long gun type uranium bomb, named Little Boy was released from a B-29 bomber Enola Gay, piloted by Colonel Paul Tibbets, from a height of 31,600 feet. The bomb exploded at an altitude of

1,000 ft, killing 70,000 people, injuring 51,000, destroying more than 70,000 houses and rendering 170,000 people homeless. After watching the detonation, Robert Lewis, the copilot scribbled in his logbook "MY GOD". Tibbets later said, that if Dante the 13-14th century Italian Poet who wrote the classic *Inferno* "has been on the plane with us he would have been terrified." Three days later on August 9, an implosion type plutonium bomb named the Fat Man was to be dropped on the industrial city of Kokura. But as the clouds and smoke were covering the target, the city of Nagasaki was chosen as the target. This deadly bomb caused 40,000 deaths and 100,000 casualties. Charles Sweeny, who earlier watched the Hiroshima explosion also from his plane, piloted the B-29 bomber Bock's Car from which the bomb was dropped. The Second World War ended on August 11. Sweeny said in 1995, "I hope my missions were the last of their kind that will ever be flown."

According to Prof. Robert James Maddox of PENN State University "Some historians have argued that while the first bomb might have been required to achieve Japanese surrender, dropping the second constituted a needless barbarism. The record shows otherwise. American officials believed more than one bomb would be necessary because they assumed Japanese hard-liners would minimize the first explosion or attempt to explain it away as some sort of natural catastrophe, precisely what they did. The Japanese minister of war, for instance, at first refused even to admit that the Hiroshima bomb was atomic. But a few hours after Nagasaki he told the cabinet that 'the Americans appeared to have one hundred atomic bombs . . they could drop three per day. The next target might well be Tokyo.'"

In a press release after the Hiroshima bombing, President Truman said, "The Japanese began the war at

Pearl Harbor. They were repaid manifold...... We have now added a new revolutionary increase in destruction to supplement the growing power of our armed forces. In their present form these bombs are now in production and even more powerful forms are in development........"

The US decision to use the atom bombs on the civilian populations of Hiroshima and Nagasaki was the subject of serious debate. It brought adverse criticism even from the top commanders of World War II. General Dwight D. Eisenhower, the Supreme Commander of Allied Forces in Europe and later the US President (1953-61) in his book *Mandate for Change, 1953-56 (*1963) observed," I had been conscious of a feeling of depression and so I voiced to him (Stimson, Secretary of War) my grave misgivings, first on the basis of my belief that Japan was already defeated and that dropping of the bomb was completely unnecessary and secondly because our country should avoid shocking the world opinion by the use of a weapon........ as a measure to save American lives." In an interview given to the Newsweek Journal in 1963, he was more candid by observing, "It was not necessary to hit them with that awful thing."

Admiral Leahy, President Truman's Chief of Staff said, "The use of this barbarous weapon at Hiroshima and Nagasaki was of no material assistance in our war against Japan. The Japanese were already defeated and ready to surrender. In being the first to use it we ——— adopted an ethical standard common to the barbarians of the Dark Ages. I was not taught to make war in that fashion and wars can't be won by destroying women and children." According to Richard M. Nixon, US President (1969-74), General Douglas McArthur, Commander of the Allied Force in the Pacific during World War II, felt that it is a tragedy that the bomb was even exploded.

H.G. Wells, who was the first to conceptualize the atom bomb, wrote in the *Sunday Express* after Hiroshima, " There is no way out, around, or through the impasse" and "even the unobservant are betraying by fits and starts a certain wonder, a shrinking fugitive sense that something is happening so that life will never be the same." Wells died the following year.

Albert Einstein after watching the damage to Hiroshima and Nagasaki said,"I made one of the biggest mistakes in my life when I signed the letter to President Roosevelt recommending that the atom bombs be made but there was some justification – the danger that the Germans could make them." He further said in December 1945, "The war is won but peace is not."

Mahatma Gandhi said, "As far as I can see, the atomic bomb has deadened the finest feelings which have sustained mankind for ages."

According to a Russian biologist, the Americans had plans to "wipe from the face of earth .... all that has been created through the centuries by the genius of mankind."

Radha Binod Pal, the Indian Jurist in the eleven member war crimes tribunal that tried the Japanese leaders, was the only judge who pronounced a not guilty verdict. He described the atom bombings of Hiroshima and Nagasaki as the worst atrocities of the war, comparable with the German Nazi crimes.

Peter Kuznick, Director of Nuclear Studies Institute at the American University observed that Truman knew that "he was beginning the process of annihilation of the species. It was not just a war crime; it was a crime against humanity."

Truman's stance on the use of the atom bombs is revealed through an episode. Oppenheimer, called the father of the atom bomb, once told the President that some scientists felt they had blood on their hands for what has been accomplished at Hiroshima and Nagasaki and, for what the world could expect in the future. An infuriated President would say later that he pulled out his handkerchief and handed it to Oppenheimer, asking, “Here, would you like to wipe the blood off your hands?” After Oppenheimer left the Oval Office, Truman turned to an aide and said, “I don’t want to see that son of a bitch in here ever again.”

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Soviet Union joins the Arms Race

In one of his meetings Truman asked Oppenheimer

"When will the Russians be able to build the bomb?"

"I don't know," said Oppenheimer.

"I know"

"When?"

"Never" Truman said.

This optimistic statement by Truman was based on the briefing by Groves that uranium is rare in the earth, that the US has done a great job by acquiring most of it from Belgian Congo and that world's supply of uranium could last only till 2000. There was, in addition, a strong confidence that the uranium enrichment process was too complex for the Soviet scientists to master.

During the Potsdam Conference Truman casually mentioned to Stalin on June 24, 1945, that the US has "a new weapon of unusual destructive force." He did not say that it was an atom bomb. Stalin replied in a cool way that he hoped it would be used against Japan. Truman, in an interview on a later occasion said he was certain that Stalin knew nothing, "he knew no more than the man in the moon." The Soviet Archives however clearly indicate that Truman misjudged Stalin. The Soviet Union was getting information on the Manhattan Project through its spy network operating in the US. Marshal Zhukov, the most successful Russian General of World War II, who led the successful assault on Berlin in April/May 1945, noted in his memoirs that on the evening of Truman's casual conversation Stalin took Molotov, the Soviet Foreign Minister, aside and said, "We need to discuss with Kurchatov the acceleration of our work."

The Soviet nuclear research programme actually began in 1942 under the leadership of I.V. Kurchatov, a distinguished physicist, in the wake of intelligence reports of the Soviet spy network about the rapidly progressing Manhattan Project. The spy network could infiltrate the project gather and pass on vital information because of the weak US security screening necessitated by the time targets set for the vast project. Klaus Fuchs, a Germany born British theoretical physicist working at the Los Alamos unit with the British team was by far the most important channel for the transmission of data on the technology of the atom bomb to the Soviet Union. He was later sentenced to fourteen years imprisonment and stripped of his British citizenship. The other notable spies were the Rosenbergs, the American couple involved in coordinating and recruiting an espionage network. They were sentenced to death and executed. Another name that recently came to light is that of George Koval, an American-born Soviet spy. He gained wide access to America's atomic plants, a feat unknown to any other Soviet spy. According to a US scientist Koval "had access to everything." He fled the US after the war and Washington kept this a secret. Koval was posthumously honoured by President Putin of Russia in 2007. In the citation Koval was described as the only Soviet intelligence officer "who helped speed up condensing the time it took for the Soviet Union to develop an atomic bomb of its own." President Putin also revealed on a Larry King Live Show on September 8, 2000, that American scientists cooperated in the Soviet bomb project. But he did not reveal any names. Ironically even Robert Oppenheimer, the Director of the US bomb project, who was believed to be a member of the hidden Communist Party of all Professionals at Berkeley, was accused of acting as a Soviet spy! In 1953 at the height of anti-communist feeling in the US, he was accused of having Communist sympathy and his security clearance was withdrawn. It is speculated that the technical data smuggled by the spy network helped the Soviet nuclear weapons programme gain by as much as a decade.

On hearing about the bombing of Hiroshima, Stalin was reported to have told the leaders of the Soviet nuclear weapons programme, "Hiroshima has shaken the whole world. The balance has been destroyed." He then made the development of the atom bomb the highest national priority. Lavrenti Beria was given overall charge of the project with Kurchatov as the Scientific Director. Based on intelligence data, the Russians initially adopted the complex gas diffusion method for enriching uranium for bomb production. But on learning that plutonium produced in a nuclear pile could be a less complex path, they proceeded to build nuclear reactors using the stolen Hanford reactor designs for producing plutonium. The first prototype nuclear reactor with a small power output became operational in December 1946. This was followed by larger plutonium-producing reactors, which provided the plutonium required for the Soviet bombs.

The major problem for the Soviet Union in the initial stages was the procurement of uranium ore. The fuel for the first reactor was obtained through confiscating the remains of the aborted German bomb project. This uranium, mined in Belgian Congo had fallen into the hands of the Germans when they overran Belgium. Another source of uranium was the St. Joachimsthal deposit. After Germany's surrender Stalin pressurized the Czechoslovakian Government to sign a secret treaty to supply all the uranium ore in St. Joachimsthal mine and also provide the labour force required for its mining. Unaware of this secret treaty, Jan Masaryk, the Czech Foreign Minister, declared in the United Nations General Assembly that the Czech uranium would never be used for mass destruction. He was reprimanded for this speech. Two weeks after the Communists captured power in Prague in 1948, Masaryk was found dead. He is believed to have been murdered. The Soviet Union also sent its prisoners of war to bring back the St. Joachimsthal mines into operation. As their number was not sufficient, the locals rounded up on ideological grounds were forced to work in the mines.

Shortly after the Red Army moved into Ore Mountains in the Schlesma Valley in occupied East Germany, prospectors identified some of the richest deposits of uranium ever found outside of Africa. Forming a state-controlled mining company under the name Wismuth, the Russians started uranium mining operations, using forced labour as was done in St. Joachimsthal. Eventually rich uranium sources were identified inside the Soviet Union itself.

The early Soviet nuclear weapons related activities were located in several cities. Some important cities are: Arzamos 16 (now Sarov), Svedlovsk-44(now Novouralsk), Chelyabinsk-40, later -67 (now Ozyorsk), Sversovsk-45 (now Losnoy), Tomsk-7 (now Seversk), and Krasnoyask-26 (now Zeleznogork).

The first Soviet bomb – an implosion type using plutonium, named Joe-1, was exploded at the Semipalatanisk Test Site in Kazakhstan at 07.00 hrs on August 29, 1949. The bomb had an explosive power of 26 kilo tons. It took more than two years before a second bomb Joe-2 was exploded on September 24, 1951. This bomb had a yield of 38 kilo tons.

The 1949 Soviet test thus ended the American monopoly over nuclear weapons. This event also marked the beginning of the Cold War era. Ironically it was just about this time that the American intelligence reported that a Soviet nuclear weapon explosion would not take place before 1953!

The American response to the Soviet Union was to launch a crash programme not only to build a big arsenal of atom bombs but also develop the more destructive thermonuclear weapon - the hydrogen bomb.

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UK, France and China join the Race

United Kingdom's atom bomb programme began as early as 1940-41 with the theoretical studies of the refugee scientists Otto Frisch and Rudolf Peierls. Their conclusions were presented to Sir Henry Tizard, the chairman of an important committee for the defence of the country. On Tizard's suggestion, a committee known as the MAUD Committee (Military Application of Uranium Detonation Committee) was constituted with G.P.Thomson, M. Oliphant, P.M.S.Blackett, J. Chadwick, P. B. Moon and J. Cockcroft to study the conclusions. The original authors Frisch, a German and Peierls an Austrian, were officially classified as "enemy aliens" and as such could not be part of this wartime committee! The Committee prepared two reports. The first report concluded that it is feasible to assemble an atom bomb using enriched uranium. The second report concluded that it is also possible to extract energy through controlled fission of uranium in a "uranium boiler." Ironically it is the Maud Committee report that alerted the Soviets, through espionage, about the bomb! The British scientists started working on the first report under the code name TUBE ALLOYS. But the British Government, already at war with Germany, realized that with its limited sources it was not possible to undertake this expensive developmental work. Tizard, accompanied by Cockcroft, led a mission to Washington to explore the possibility of shifting this programme to the US. These negotiations led to UK along with Canada becoming a partner in the tri-national Manhattan Project under the Quebec Agreement signed in 1943. The British scientists made major contributions to the Manhattan Project. More significantly their participation in the Manhattan Project and the work carried out at the Montreal Laboratory and Chalk River Project in Canada helped them gain expertise in the atom bomb assembly.

Though a significant number of immigrant scientists from Britain, Germany, Hungary, Austria and Denmark played a major role in the Manhattan Project, it was the US scientific community and bureaucracy that controlled and dominated the entire show. At one stage Leslie Groves said that "the United States could have got along without them (the British)." He even excluded the British scientists from participating in the assembly of the Hiroshima and Nagasaki bombs. Through the adoption of the Atomic Energy Act of 1946 (known as the McMahon Act) the US Government got complete authority to control and manage the nuclear technology keeping away its wartime British and Canadian allies. With this development UK under the new Labour Government headed by C.R. Attlee decided to build its own nuclear capability. According to one observer,"Possession of the bomb was a symbol of prestige and a sign of power that seemed perfectly normal for a nation that as yet had not realized that it had lost its empire and its former world status." A team was constituted for the bomb production. It consisted of Lord Portal (Air Marshal) (considered as the "British Leslie Groves") as the Controller of Production, Sir John Cockcroft, as the Director of the Atomic Energy Establishment, and Christopher Hinton, an engineer, as the leader of fissile material production. One unique feature of the programme was that it comprised both civilian (power generation) and military (atom bomb production) components.

The programme started at the Atomic Energy Establishment located at Harwell. The first British nuclear pile became operational at Harwell in August 1947. Reactors for civilian power supply and for production of weapons grade plutonium were located at Windscale (later named Sellafield). During the periods the reactors were not required for producing plutonium for weapons, their operation was optimized for electricity generation for civilian use. A reprocessing facility was constructed for the separation of plutonium and uranium from the spent fuel. The Atomic Weapons Research Establishment was established in 1950 at Aldermaston for the bomb assembly. Sir William Penney, a senior physicist with considerable experience in the Manhattan Project, was chosen for designing the bomb. The first plutonium supply from Windscale was ready by March 1952. But as the plutonium needed for the first bomb was not sufficient for its assembly and testing on schedule, some plutonium was secured from the Canadian sources. Due to the small size and high population density of UK there was no suitable site for atmospheric tests. It had therefore to seek a site in other countries for testing. The first British plutonium bomb under the code name OPERATION HURRICANE was detonated in the Monte Bello Islands, off the coast of Western Australia on October 3, 1952. The bomb had a yield of 25 kilotons. This achievement prompted Sir Leonard Owen, a scientist to say that," the McMahon Act was probably one of the best that happened...... as it made us work and think for ourselves along independent lines."

Nuclear research in France began well before World War II with the Curie and the Joliot-Curie couples making classic contributions in the field. But after France came under German occupation the French scientific community was put to great disadvantage having been sequestrated from the wartime nuclear programmes in the US. The only exception was Dr. Bernard Goldschmidt who worked with the Anglo-Canadian team at Chalk River and developed the first extraction process for separating plutonium from used nuclear fuel. This process has since become the international standard method.

After the end of the war the French Atomic Energy Commission was constituted by the French provisional government headed by General de Gaulle with authority to pursue the scientific, commercial and military aspects of nuclear science. Frederic Joliot-Curie was designated as the High Commissioner. In the early stages the programme languished due to political problems with the French communists opposing nuclear proliferation. After the replacement of Frederic Joliot-Curie, himself an ardent communist, by Francis Perrin in 1951 the activity gained momentum. The discovery of large uranium deposits in Central France provided an unrestricted supply of uranium for the construction of nuclear reactors. The French Cabinet led by Prime Minister Pierre Mendes-France authorized in 1954 the programme to develop an atom bomb. The first reactor capable of producing plutonium for the bomb became operational in 1956. In the wake of the humiliating Suez Crisis in October 1956, France decided to abandon NATO's defence cover and accelerate production of its own nuclear deterrent. Felix Gaillard, the Prime Minister signed an official order in 1958 for the assembly and testing of a bomb. The programme received powerful backing from General de Gaulle who became President in December 1958. The first French nuclear test code-named GERBOISE BLEUE was conducted on February 13, 1960 at Reggane in Algeria atop a 105 m tower. This plutonium bomb had a yield of 60-70 kilotons, the most powerful conducted by any country in its first test.

China, the first Asian power to assemble an atom bomb, began its programme as early as 1951, when it entered into an agreement with the Soviet Union for technical assistance in the nuclear field in exchange for Chinese uranium ores. In October 1957 China and the Soviet Union signed an agreement for the supply a sample atom bomb by the latter and also technical help in nuclear weapon assembly. Assistance was also provided by the Soviet Union for building a gaseous diffusion plant for uranium enrichment. Despite the high cost and complex nature of its production, enriched uranium was considered a far better choice than plutonium. This is because uranium which has a low radioactivity can be handled more easily than plutonium which is intensely radioactive. The metal can also be melted and shaped by simple techniques with no danger to the craftsmen. It is said that the core of the first Chinese nuclear weapon using enriched uranium was shaped on a lathe by a single technician in one night in an ordinary machine workshop!

The Soviet Union appears to have expected to retain control over the use of the Chinese nuclear weapons. On the other hand China expected to have full freedom to use the weapons. On this count China walked out of the agreement. After the departure of Soviet experts China pursued the programme on its own and succeeded in producing the enriched uranium required for a bomb. The first Chinese nuclear test was conducted at Lop Nor on October 16, 1964. The bomb had a yield of 25 kilotons.

The Five veto-wielding permanent members of the UN Security Council thus constituted the Nuclear High Table.

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The Super (Hydrogen) Bomb

The energy from the Sun and other stars, the driving force that sustains life on Earth, is generated in their cores through the fusion of four hydrogen nuclei forming one helium nucleus. This fusion process called *thermonuclear fusion* requires very high energy, equivalent to temperatures of the order of fifteen million degrees, to overcome the electrostatic repulsion of the positively charged nuclei to undergo fusion and liberate energy. The energy required is generated in a star's core through compression of the hydrogen material under gravitational pressure. The energy we receive from the Sun, our nearest star, is generated through the thermonuclear fusion of 2.0×10^{19} kilograms of hydrogen annually at a steady rate. Compared with an estimated total mass of 2×10^{30} kilograms of hydrogen present in the Sun this conversion rate is slow and hence can be considered occurring at a steady rate. According to cosmologists the energy from the Sun can remain in this steady and balanced state for ten billion years. Given that the Sun's age is about 4.6 billion years we can hope that Sun's energy can sustain life on Earth for about five billion more years.

Is it possible to replicate such a thermonuclear fusion reaction by man through creating temperatures of the order of fifteen million degrees? Tokutaro Hagiwara contemplated in a lecture in 1941 at the Tokyo University that this is possible through creating temperatures of this order by means of uranium fission and ignite a hydrogen fusion reaction.

But it was Edward Teller, an émigré scientist from Hungary working in the Manhattan Project, who pursued the development of a thermonuclear weapon or a "super atom bomb" based on this principle. He argued that because of the difficulties in handling large critical masses of fission material (plutonium or enriched uranium) there is an upper limit to the explosive yield in the design of a fission bomb. For example, a fission bomb containing 60 kg of enriched uranium, the maximum quantity that can be handled, would give an explosive yield of 500 kilotons TNT equivalent of energy. Teller pointed out that there is no such upper yield limit for a thermonuclear weapon and the explosive power could theoretically be many thousand times more, in the megaton range. Such a powerful weapon would provide the US with an unmatched military superiority.

Oppenheimer, Frisch, Rabi, Urey, Einstein and other scientists opposed the development of such a weapon. Frisch and Rabi wrote, "Since no limit exists for the destructiveness of this weapon, its existence and knowledge of its construction is a danger to humanity as a whole." In the wake of the escalation of the Cold War, the pro-bomb lobby led by Teller prevailed. The Joint Chiefs of Staff told Truman "that the hydrogen bomb could improve our defence in its broadest sense, as a potential offensive weapon, a possible deterrent to war, a potential retaliatory weapon as well as a defensive weapon against enemy forces." Truman asked a specially constituted Committee of the National Security Council "Can the Russians do it?" All agreed they could. Truman replied, "We have no choice. We will go ahead." On January 31, 1950 Truman announced ".......I have directed the Atomic Energy Commission to continue its work on all forms of atomic weapons including the so-called hydrogen or super bomb." Savannah River in South Carolina was chosen as the project site. The reactants chosen for assembling the bomb were the heavier isotopes of hydrogen with unit masses 2 (Deuterium or heavy hydrogen) and three (Tritium). Ordinary hydrogen has a single unit mass. Deuterium is present in all natural waters to the extent of one part in 5,600 parts and can be easily separated. Tritium is prepared in a nuclear reactor. In the fusion reaction between each nucleus of Deuterium and Tritium, huge quantities of energy are liberated. Alternately

Deuterium nuclei also can be subjected to fusion with a similar effect. Additionally neutrons are also generated and these can be used for enhancing the destructive power of the device. The hydrogen bomb works on a two stage design. Initially an atom bomb is detonated using the conventional implosion method. This fission step provides the heat necessary for the Deuterium and Tritium nuclei to undergo fusion forming heavier elements and releasing tremendous energy.

The feasibility of a hydrogen bomb was first tested by the US military on May 9, 1951 through a test codenamed GEORGE during Operation Greenhouse at the Pacific Proving Grounds in Eniwetok Atoll. Most of the explosion came from the fission fuel component but it substantiated the idea that an atom (fission) bomb could be used as a "stepping stone" to a more destructive weapon. A similar test, named ITEM, was conducted on May 25, 1951.

The first US hydrogen bomb was exploded on November1, 1952. Eulegelab, a small island in the Eniwetok Atoll of the Marshall Islands in the Pacific was chosen as the test site. Using liquid Deuterium-Tritium as fuel (cryogenic fusion fuel), the bomb, nicknamed IVY MIKE, required 18 tons of refrigeration equipment to keep the gaseous medium in the liquid form. The bomb exploded with a force equivalent to 10 megatons, thousand times more powerful than the Hiroshima bomb. The blast, shining as brightly as thousand Suns, was more stunning than the fission blast. The cloud, when it reached its farthest extent was about hundred miles wide and 25 miles high. It gouged a crater two miles wide and several hundred yards deep, completely wiping out the Eulegelab test island. This successful test has ushered in the era of megaton nuclear weapons.

This design with cryogenic fuel was however not suitable for use as a deliverable weapon. This problem was solved by choosing the fuel core in the form of a solid lithium deuteride and fusion of deuterium nuclei as the energy generating reaction. This design is known as the Teller-Ulam design, named after Edward Teller and Stanislaw Ulam, its major contributors. This bomb, nicknamed SHRIMP was tested at Castle Bravo on the Bikini Atoll in Marshall Island on March 1, 1954. With a yield of 15 megatons this became the first practical deliverable thermonuclear (hydrogen) bomb. The test explosion showered radioactive material on Japanese fishermen in the vicinity and the residents of Marshall Island. One fisherman died of radiation sickness. This event prompted a world-wide demand for a ban on nuclear weapon testing. The successful Teller-Ulam design has come to be adopted by all thermonuclear weapon-producing nations.

With the appearance of the atom bomb in 1945 the explosive power of the global range weapons has multiplied by thousands and then with the hydrogen (thermonuclear) bomb by millions. Destruction on a scale far beyond anything experienced before, accompanied by uncontrollable and persistent poisoning of the environment by radioactive fallout has thus become a threat to humanity.

This nuclear advantage gained by the US was however short-lived. The Soviet scientists under the leadership the 30 year-old scientist Andrei Sakharov, accelerated work on the hydrogen bomb project. It is believed that the technical data provided by the Soviet spy Klaus Fuchs proved very helpful in this task. Georgy Malenkov, Chairman of the Council of Ministers of the Soviet Union, addressing the Supreme Soviet on August 8, 1953 said, "The Government deems it necessary to report to the Supreme Soviet that the US has no monopoly on the production of the hydrogen bomb either." His statement was immediately followed by the Soviet Union detonating a hydrogen bomb with 400 kiloton power (nicknamed Joe 4 by the Americans) on

August 12, 1953 at the Semipalatinisk Test Site in Kazakhstan. The first Soviet test of a true hydrogen bomb in the megaton range, named Joe 19, was detonated on November 22, 1955. It had a yield of 1.6 megaton. On October 30, 1961 the Soviet Union exploded the super bomb "Tsar Bomba" with a yield of 50-60 megatons on Novaya Zemiya Island in the Arctic. This bomb, originally designed for 100 megatons and later scaled down, is equivalent to 1,400 times the combined power of the two atom bombs that destroyed Hiroshima and Nagasaki and ten times the power of all explosives used during World War II. It is also the single physically most powerful device ever exploded by man.

In July 1954, the British cabinet, after a heated debate during which Prime Minister Churchill even threatened to resign, authorized the production of "thermonuclear bombs." The White Paper issued in February 1955 announcing this decision said, "Communist policies may appear, from time to time, more accommodating. But Communist actions have so far provided no real ground for believing that the threat to the Free World has sensibly diminished." The yields from the initial British tests in 1957 were well below the expected levels. The first successful hydrogen bomb was detonated on November 8, 1957 over Christmas Island in the Pacific. The test gave a yield of 1.8 megatons. "Even if you do not have a big stick, it is sometimes wise to say you do."

After the British scientists demonstrated their capacity to develop a hydrogen bomb, the US McMahon Act was amended in 1958 restoring US-UK cooperation in nuclear programme. The UK discontinuing its own tests began adopting the fully developed American designs which were cheaper.

On realizing in 1965 that China was going to get the hydrogen bomb, General de Gaulle became impatient about the slow progress in the French efforts in this direction. The scientific community led by Roger Doultry and Michel Carayol were spurred into action. France however did not have the ability to produce the Deuterium (heavy water) needed for the device. The heavy water required was purchased from Norway and US and used for the production of Lithium Deuteride and Tritium. The first thermonuclear bomb, under the code name CANOPUS0, was detonated by France on August 24, 1968 at the Fangataufa in the nuclear testing grounds, Mururoa, in French Polynesia in the Pacific. The device was suspended from a large hydrogen-filled balloon and detonated at an altitude of 1,800 feet. The bomb had a yield of 2.6 megatons.

As early as 1960, the Chinese scientists began to explore the possibility of assembling a hydrogen bomb. The programme gained momentum after their successful detonation of the atom bomb in October 1964. In less than 32 months, China detonated its first hydrogen bomb at Lop Nor in Western China on June 17, 1967. The bomb, which had a yield of 3.31 mega tons, was dropped from an airplane and detonated at an altitude of 2,960 metres.

It took the US more than seven years from its first atom bomb test to detonate its first hydrogen bomb, the Soviet Union four years and the UK four and a half years. In contrast, China took only two years and two months, the shortest elapsed time for any nuclear weapons nation!

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Nuclear Weapons Build-up

The first UN General Assembly which met in London in January 1946 initiated steps to eliminate all weapons of mass destruction including the atomic bomb. As part of this goal, the US presented a plan known as the Baruch Plan (named after its author Bernard Baruch) for the establishment of an international authority to control the potentially dangerous atomic activities, license the programmes and carry out inspections. The Soviet Union rejected the plan since it would have given the US decisive nuclear superiority and also could have stopped the Soviet nuclear programme. In the absence of an agreement, the atomic weapons building activity was pursued vigorously by the US and its allies UK and France as well as the Soviet Union and its China ally. Thus began the era of Cold War marked by intensive testing programmes and weapons build-up casting a nuclear shadow over the world "like a giant gloomy mushroom tattoo." The term Cold War came "from the fact that it never became a shooting war *per se,* but more of a cat and mouse game!"

No nuclear weapon was used in a war after Hiroshima and Nagasaki. But nuclear weapon testing has been carried out throughout the 20th century by different nations. The object of testing was to determine the effectiveness, yield and explosive capability and behavior of different types under various conditions. More importantly a weapon testing has often been used by countries to proclaim their scientific and military prowess. Most of the countries (including India, Pakistan and North Korea) declared their nuclear status by means of nuclear tests.

Beginning with the first ever test carried out by the US on July 16, 1945, there have been 2,044 tests worldwide, the equivalent of one test occurring somewhere in the world every nine days for the last fifty years, says a 1996 report of Greenpeace. Of these, the US carried out 1,030 nuclear weapons tests (equivalent of one test every 17 days since the first test), the last and final test being the one on September 23, 1993. The Soviet Union conducted 715 tests (on average one test every 23 days) with the last one on October 25, 1990. France conducted 210 tests (one in every 63 days) ending with the final test on January 27, 1996. UK carried out 45 tests (one in every 349 days), with the last and final test held on November 26, 1991. China conducted 45 tests (one every 222 days). Other countries that conducted tests include India (seven), Pakistan (six) and North Korea (two) (to be described later). Additionally there have been at least three unacknowledged tests.

Worldwide 711 tests have been conducted in the atmosphere or under water. It is estimated that the total yield of all the atmospheric weapons tests conducted was 438 megatons. This is equivalent to 29,200 Hiroshima size explosives. In the 36 years between 1945 and 1980, when atmospheric testing was going on it would have been equivalent to exploding a Hiroshima size bomb in the atmosphere every 11 hours! It is estimated that about 4,200 kilograms of plutonium, the most toxic element, has been discharged into the atmosphere from atmospheric testing and about 3,830 kilograms as a result of underground testing. Radioactivity has leaked into the atmosphere and water sources from atmospheric tests and into the soil and ground waters, turning large areas of land uninhabitable by the indigenous people and affecting their livelihoods. The American Scientist journal stated in 2006,"There was no place on Earth where the signature of atmospheric nuclear testing could not be found in soil, water and even polar ice." With rising concern about radioactive fallout as result of testing in the atmosphere, underwater, or on the ground surface, nations have entered into a treaty, called the Partial Test Ban Treaty, banning nuclear weapon tests in the atmosphere, in the outer space and underwater to stop the excessive release of nuclear fallout into the planet's atmosphere and thence into the ecosystem. With this treaty coming into force on October 10, 1963, all tests were conducted underground thereafter. China and France however have reportedly conducted surface tests till 1996. The US conducted underground tests till 1992, the Soviet Union till 1990, and the UK till 1991.

Another treaty known as the Comprehensive Test Ban Treaty (CTBT) has been adopted by the UN General Assembly and opened for signatures in 1996. Under this treaty, nations have pledged to discontinue all nuclear testing. However Article XIV requires ratification by 44 designated nuclear capable states before the Treaty enters into force. As of 2012 China, Egypt, Indonesia, Iran, Israel and the US have signed the Treaty but not ratified it. India opposed the Treaty on the ground that it was discriminatory and inadequate in terms of securing disarmament commitment from the nuclear weapon states under declared deadlines. Pakistan and North Korea also did not sign the Treaty.

The US and Soviet Union have also conducted "PEACEFUL NUCLEAR EXPLOSIONS" for various purposes such as deep seismic sounding, creating underground storage cavities, extracting gas and oil, extinguishing gas or oil wells, creating reservoirs and help building a canal. India's nuclear test in 1974 was ostensibly 'for peaceful purposes'.

By 1993 about 127,000 nuclear warheads have been built by the US and Soviet Union. These represent 98 per cent of the global nuclear weapons output with UK and France accounting for almost 2 per cent. Israel, India, Pakistan an Korea also built a relatively smaller number of weapons. These weapons are broadly categorized as *Strategic* and *Tactical* nuclear weapons. The strategic weapons, with yields greater than 100 kilotons and upto megatons, are designed to be used as part of a strategic plan, against targets such as nuclear missile bases, military command centres, and heavily populated civilian areas such as towns and cities. These are dropped from big bombers (e.g. B-29, B-36, B-52 and B-61) and also launched through long range delivery systems such as the Intercontinental Ballistic Missiles (ICBMs) and Submarine Launched Ballistic Missiles against targets thousands of kilometers away. In contrast, tactical weapons are smaller short range weapons with yields in the 15-100 kiloton range. These are designed to be used in a battle, as part of an attack by conventional (land, air or air) forces aiming at the accomplishment of a specified military mission. Briefly stated Intercontinental Ballistic Missiles (ICBM) with nuclear warheads with long ranges (thousands of miles) represent the primary strategic nuclear weapons while short range missiles with nuclear warheads constitute tactical weapons. This distinction between the strategic weapons and tactical weapons has however dissolved with advances in delivery systems and their accuracy. A strategic weapon can be used for tactical purposes and vice versa. But from non-proliferation point of view, the tactical (non-strategic) weapons pose a much greater danger than their strategic counterparts. This is because they are more vulnerable for non-authorized use, including theft, than strategic weapons, which always have dedicated delivery systems, better physical security, and better established and mature methods and procedures.

Decades of rushed and largely secretive production of plutonium and enriched uranium for nuclear weapons has left immense legacies of contamination and toxic nuclear wastes in the major nuclear weapons-producing countries of US and Soviet Union. As many as 113 locations in the US were engaged in the production of 70,000 bombs and warheads between 1940 and 2000. Of these, just two bombs were used over Japan in 1945! During this period the US has spent about $400 billion for weapons production and an additional $5 trillion for developing the delivery systems (e.g. missiles, submarines) and related equipment! According to US Department of Energy (DOE) report of 1998, the cleanup operations of nuclear weapons production sites involve:

Remediating 1.7 trillion gallons of contaminated water, an amount equal to approximately four times the daily US water consumption, Remediating 40 million cubic metres of contaminated soil and debris, enough to fill approximately 17 professional sports stadiums, Safely storing and guarding more than 18 metric tons of weapons grade plutonium, enough for making thousands of nuclear weapons, Managing over 2,000 tons of intensely radioactive spent nuclear fuel, some of which is corroding, Sorting, treating and disposing of radioactive and hazardous waste, including 160,000 cu.m. currently in storage and over 100 million gallons of liquid high level radioactive waste, Deactivating and/or decommissioning of about 4,000 facilities that are no longer needed, Implementing critical non-proliferation programmes for accepting and safely managing spent fuel from foreign research reactors, and Providing long-term care and monitoring or stewardship at about 109 sites for hundreds of years following clean up.

The DOE in its report in 2000 estimated that from $151-195 billion will be needed through the year 2070 for cleaning up the US nuclear weapons facilities. A Los Angeles Times report of October 20, 2009 says that so far $ 100 billion have been spent and the cost is expected to total over $330 billion over next three to five decades. Meanwhile a February 2013 report says that six of the 177 underground tanks at Hanford, Washington State, (considered as America's most contaminated nuclear site) holding a mix of radioactive and toxic wastes are leaking.

These tanks were installed decades ago are past their intended life span of 20 years. These tanks contain some 83 million gallons of highly radioactive waste enough to fill dozens of Olympic size swimming pools.

Throughout the Cold War period the former Soviet Union developed and built its nuclear weapons in a number of secret nuclear sites spread across the country. The Mayak (formerly known as Chelyabinsk) area, one of the main centres for producing nuclear weapons and reprocessing of spent nuclear fuel for plutonium extraction is considered as the most contaminated spot on the planet. It suffered at least three serious accidents exposing a huge swathe of 35,000 sq.miles to intense radiation. Lacking adequate infrastructure for storing or managing the spent fuel and radioactive wastes, the Soviet Union has dumped its wastes into the water bodies. In the early years of operation the Mayak plant released huge quantities of radioactivity contaminated water into the several nearby lakes, whose waters ultimately flow into the Ob River. Waste waters were pumped into Lake Karachai, a 100 acre water body with no outlet, until the radioactivity accumulated to 120 million Curies. The contaminated water is reported to be seeping into the Arctic too. In November 2000 it was revealed that dangerous levels of radioactivity are entering the Tom River from the nuclear facility at Tomsk 25 km away. The Soviet Union has been responsible for dumping in the sea twice as much nuclear wastes and spent fuel as the rest of nuclear powers of the world. Between 1956 and 1992 one to three million Curies (equivalent to the activity of one to three million grams of radium) were dumped at sea. About 20 reactors from nuclear submarines have been dumped in the Sea of Japan and Arctic Ocean.

With the breakup of the Soviet Union, the Russian state has inherited, as a Cold War legacy, nuclear material consisting of spent nuclear fuel and radioactive waste from

200 nuclear submarines and surface ships, posing a significant threat to the environment in the North West and Far East. More than 100 Soviet nuclear submarines, virtually abandoned, await decommissioning. Dismantling each submarine is estimated to cost $25 million. Several countries including the US have come to the assistance of cash-strapped Russia for the elimination of this Cold War legacy and also take steps for the safe upkeep of the plutonium and enriched uranium recovered. The progress has however been very tardy.

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The Nuclear Cartels

After the nuclear attack on Japan, President Truman asserted that the US alone must act as the "trustee of this new force" and directed the State Department to take appropriate steps in this direction. The Baruch plan formulated with this objective and debated by the UN Assembly did not get approval due to opposition from the Soviet Bloc. The US then passed the Atomic Energy Act (McMahon Act) of 1946, which made the entire US nuclear programme a secret.

By the time General Eisenhower became the US President, the USSR and UK joined the nuclear club. Eisenhower and his advisors felt that Moscow's growing mastery of nuclear technology meant that the Kremlin, by providing peaceful nuclear assistance to other countries, especially developing countries, would score a huge propaganda victory. It should therefore revise its own nuclear export policy to counter this. As a part of this strategy Eisenhower in his speech delivered before the UN General Assembly on December 8, 1953, announced the *ATOMS FOR PEACE PROGRAMME* "to hasten the day when the fear of the atom will begin to disappear from the minds of the people and the governments of the East and West." To this end he proposed the constitution of the International Atomic Energy Agency under the UN with responsibility to devise methods for applying atomic energy to the needs of agriculture, medicine, and other peaceful activities and more importantly to provide abundant electrical energy in the power-starved areas of the world. He further said, "The US pledges before you - and therefore the world - its determination to help solve the fearful atom dilemma - to devote its entire heart and mind to find the ways by which the miraculous inventiveness of man shall not be dedicated to his death but consecrated to his life." Some people believed that the move hinted at a sense of guilt on the part of the US Government for the nuclear attacks on the Japanese civilian population.

The International Atomic Energy Agency (IAEA) was established as an autonomous body in August 1957 with its headquarters in Vienna with three missions:

Peaceful Uses - Promoting peaceful uses of nuclear energy by its member states

Safeguards - Implementing safeguards to verify that nuclear energy is not used for military purposes

Nuclear Safety- Promoting high standards for nuclear safety

The Eisenhower administration simultaneously took steps to disprove the Communist propaganda that the US is solely concerned with the destructive use of the atom. To maintain US global leadership and reduce Soviet influence, the US Atomic Energy Act was amended in August 1954, permitting the US to export nuclear technology and nuclear materials if the recipient country committed itself not to use these items for developing nuclear weapons. At the First UN International Conference on Peaceful Uses of Atomic Energy held at Geneva in 1955 under the Chairmanship of H.J. Bhabha, Chairman of India's Atomic Energy Commission, the US presented hundreds of declassified documents on nuclear energy. It also entered into nuclear cooperation with several countries for extending assistance in the development of nuclear energy for peaceful purposes. Most importantly, friendly nuclear nations were given training, technical information and help in constructing small nuclear research reactors. The US Atomic Energy Commission Act was also amended permitting the supply to these friendly nations limited amounts of raw and fissionable materials as well as providing assistance for building power reactors.

With an eye on scientific, commercial and political benefits, the US state and commercial establishments concerned with exports did not pay adequate attention to the security aspects of nuclear programmes and the ulterior perceptions of the recipient countries. As a result, the safeguards system enacted by the US proved ineffective. The IAEA, still in its formative stage, was also not in a position to spell out and enforce an effective safeguards regime.

The US export policy "ordinarily" required the recipients of the of the fissile materials or reactors to send the used fuel elements back to US for chemical processing, establish adequate inventory and other control technologies and eventually implement the IAEA safeguards. But in practice these measures were not strictly enforced. Other supplier countries (UK and France) also relaxed their control regimes for commercial considerations. Some recipient countries, Israel, South Africa, India and Pakistan took advantage of the loopholes in the control regime and directed their efforts to nuclear weapons building programmes by diverting the fissile material. Ultimately the Atoms for Peace concept had to bear the blame for this development. Leonard Beaton a well known British defence analyst said in 1966," only a social psychologist could hope to explain why possessors of the most terrible weapons in history should have sought to spread the necessary industry to produce them in the belief that this could make the world safer." If the US had not launched its Atoms for Peace Programme, the road to nuclear capability would have been much rockier for these countries! Experience however shows that the spread of any technology might be slow but it could never be stopped.

By 1960s the nuclear arms race saw US, UK, France, USSR and China, the five permanent members of the UN Security Council, become nuclear weapon nations. At the same time several other countries such as Argentina, South

Africa, Israel, Egypt, India and Pakistan were moving in the direction of acquiring nuclear capability, raising concern that humanity was heading towards an uncontrollable and destructive nuclear weapons race. This frightening trend brought together the two super powers US and USSR, which had by then amassed huge nuclear arsenals and felt safe against each other. They decided that steps should be taken to prevent other nations from acquiring nuclear capability. To this end they formulated the Nuclear Non Proliferation Treaty (NPT), which was presented to the UN General Assembly in the fall of 1965. After prolonged negotiations, the Treaty in its final form was approved by the General Assembly on June 12, 1968 with 91 countries voting in favour, 4 countries (Israel, India, Pakistan and Cuba) against and 21 abstentions. Under this Treaty, states were classified into Nuclear Weapons States (NWS) and Non Nuclear Weapons States (NNWS). For purposes of the Treaty an NWS state is defined as one that has manufactured and exploded a nuclear weapon or other nuclear explosives before January 1968. US, USSR, UK, France and China thus come under the NWS category.

Under Articles I and II the NWS agree not to help the NNWS develop or acquire nuclear weapons and the NNWS agree to permanently give up pursuit of nuclear weapons. Article III empowers the IAEA to inspect the NNWS facilities and also establish safeguards for the transfer of fissionable materials between NWS and NNWS. There is however no provision for the inspection of NWS facilities by the IAEA!

Article IV acknowledges the "inalienable right" of the NNWS to develop and use nuclear energy for non-weapon purposes and also supports the fullest possible exchange of such nuclear related information and technology between the NWS and NNWS.

Article V permits NNWS access to NWS research and development benefits of nuclear explosions conducted for peaceful purposes This clause has lost relevance as the utility of peaceful nuclear explosions has since diminished.

Article VI commits the NWS to "pursue negotiations in good faith on effective measures relating to the cessation of nuclear arms races at an early date and on a Treaty on general and complete disarmament under strict effective international control." Articles VII and VIII acknowledge the necessity of intermediate steps in the process of nuclear disarmament and the establishment of nuclear weapons-free zones.

Article IX spells out the terms by which a State may withdraw from the Treaty by giving three months advance notice.

The remaining articles deal with administrative matters including provision for a review conference every five years and on decision after 25 years whether the Treaty should be extended. In 1995 Review Conference, the Treaty was extended indefinitely with a decision to evolve strategies to strengthen it.

The NPT is described as a grand bargain between the nuclear haves and have-nots with the haves preserving the advantage of a "nuclear cartel" in which a few producers control the demand from many buyers. For the super powers it meant a significant political and strategic advantage with the smaller states having no choice but ally with them for security.

The Treaty was opened on July 1, 1968 with the signatures of US, UK and USSR and 59 countries and entered into force in March 1970. China acceded in March 1992 and France in August 1992. At the time the Treaty was proposed 25-30 states were predicted to go nuclear within 20-30 years. But most of them including South Africa, Argentina, and West Germany adhered to the Treaty bringing the total number to 190. North Korea which acceded in 1985 announced its withdrawal from the Treaty in 2003, bringing down the number to 189. The clandestine nuclear programmes undertaken by Iran, which is a signatory to the NPT, is currently an issue of international concern.

Of the nations that did not accede to the Treaty, India has shown its unwillingness to sign the Treaty in its current form because it feels that the Treaty allowed the five NWS to retain nuclear weapons without a specific time schedule for nuclear disarmament, and creating two classes of states- the nuclear "haves' and the "have–nots". Pakistan has maintained that it would sign the NPT if India also signs. Israel refused to sign the Treaty on the grounds that "it is deeply flawed and hypocritical. It ignores the realities of the Middle-East and the real threats facing the region and the entire world". In an ironic twist the states (except Cuba) that opposed the NPT became Nuclear Weapon States after the NPT came into force. Israel, which is known to have developed nuclear weapon capability is yet to officially accept its NWS status.

Yet another nuclear cartel is the Nuclear Suppliers Group (NSG). Initially started with six members in the wake of India's first Pokhran nuclear test in 1974, the NSG has 46 members as of 2009. This group seeks to contribute to the non-proliferation of nuclear weapons under the Guidelines formulated for nuclear and nuclear related exports to ensure that these exports are not diverted for military purposes. The state which imports the materials should provide assurances to the NSG members that the proposed deals will not contribute to the creation of nuclear weapons. The recipient state is also expected to have safeguards in place to prevent their theft or unauthorized use and promise that the materials and information will not be transferred to a third party without the explicit permission of the exporting state. The IAEA is charged with putting in place all safeguards to prevent diversion of nuclear material or technology for military purposes.

The guideline regime however is voluntary. The guidelines are implemented by each participating state on political considerations and in accordance with its national laws and practices. For instance Russia transferred nuclear fuel to India in 2001 even though as many as 32 members declared that the action contravenes Russia's commitments to the regime.

In 2008 the NSG agreed under US pressure to exempt India from its requirement that the recipient countries have in place comprehensive IAEA safeguards covering all nuclear activities. This waiver however commits each NSG member to regularly inform the group of the approved transfers to India.

Any state that conducts exports of materials listed in the Guidelines may apply for NSG membership. The applicant state is evaluated on its proliferation record, adherence to international non-proliferation treaties (e.g. NPT) and national export controls. All existing members must approve the admission of the applicant into the NSG. Strangely the Group contains member nations such as Malta, Cyprus and Iceland which have practically negligible activity in the nuclear field. India is facing hurdles for admission into the NSG though US, UK, Russia and France gave their backing. Small states such as Ireland, the Netherlands and Switzerland expressed their reservations. China stressed the need for equal treatment to South Asia, an apparent reference to its ally Pakistan.

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Israel, a Covert Nuclear Weapons State

Israel's pursuit of nuclear weapons involved high level deception, overseas financing, circumspect diplomacy and even a suspected sea piracy in the Mediterranean.

The state of Israel was formed on May 14, 1948 after almost two millennia of Jewish dispersal and persecution. Its formation has been immediately challenged by the surrounding Arab countries, with bitter and violent confrontations continuing and no peace in sight, putting its very survival in jeopardy. Further, the "'memory that no country was prepared to help when Hitler murdered six million Jews" made "Israelis doubt that any country would come to their aid if they were being pushed into the sea." Israel resolved to covertly pursue the nuclear weapons goal for its security as early as 1949 under the leadership of Ben-Gurion, its first Prime Minister. "What Einstein, Oppenheimer and Teller, the three of the Jews, made for the United States, could also be done by scientists in Israel for their own people," Ben-Gurion declared.

A geological survey of the Negev desert revealed the presence recoverable amounts of uranium in the phosphate deposits. Extraction of uranium from these deposits began in small plants started under the cover of a fertilizer company called the Negev Phosphate Chemicals Company. The Israel Atomic Energy Commission was constituted in 1952 with Ernst David Bergmann as its Chairman. Bergmann was a stubborn supporter of an Israeli bomb to ensure "that we shall never again be led as lambs to the slaughter." After the announcement of the US Atoms for Peace programme in 1953, Israel became the second country after Turkey to sign an agreement with the US on July 12, 1955 for the construction of a small swimming pool reactor in Nachal Soreq. Using this reactor as a facade a much bigger reactor was built at Dimona in Negev Desert with French assistance. France's decision to help Israel build a nuclear reactor and chemical processing plant came in the wake of the 1956 Suez crisis to help Israel build a bomb "so that Israel could face its enemies in the Middle-East." Agreements were originally signed in October 1957 for the construction of a 24 MW(thermal) reactor for peaceful purposes. France justified its decision by citing the 1955 decision of Canada to help India build a heavy water reactor (CIRUS) for peaceful purposes. The complex was constructed in secret, and outside the IAEA safeguards regime.

The reactor actually built by France was nearly six times as large (about 150MW). The reactor tank, the largest of the reactor components was declared at the French customs as part of the desalination plant for Latin America. Great Britain extended its help by supplying chemicals needed for reprocessing, samples of enriched uranium as well as plutonium and in due course materials required for the assembly of hydrogen bombs too. Supply of 20 tons of heavy water was made clandestinely. The Dimona reactor went critical in 1962. By 1965 the reprocessing plant for plutonium separation became operational. The processing facility had the capacity to produce 40-60 kilograms of plutonium a year, enough to assemble 5-10 nuclear warheads. Despite some problems France's assistance continued till 1966.

Israel is also believed to have developed nuclear weapons using enriched uranium. Up to 100 kg of enriched uranium missing at a facility in Pennsylvania in US is believed to have been smuggled out and taken to Israel for the purpose.

Israel however faced difficulty in procuring natural uranium in quantities required for the reactor. The Negev mines were not able to meet the demand. France also withdrew support under directions from President Charles de Gaulle. Israel could not buy uranium in the open market. To get over this problem the Israel secret agency Mossad undertook a carefully planned pirate operation that has come to be known as the *Plumbat Affair*. A fictitious company was set up in Liberia in 1968 to purchase a tramp ocean freighter named Scheersberg A. This freighter was used to smuggle Yellowcake (uranium oxide concentrate powder obtained from uranium ore) worth $3.7 million stored in Antwerp, Belgium, by the Union Miniëre Company. The entire crew of Spanish-speaking sailors were disembarked and replaced with workers picked up by the Mossad. With the help of an official of a German petrochemical company, this material, under the fictitious name Plumbat, a harmless lead product (plumbum means lead in Latin), was sealed into 560 drums each with a capacity of 200 litres and loaded in the freighter declaring Genoa in Italy as destination. It was further declared that after chemical processing at Milan the material was to be shipped back to Antwerp. The freighter then headed ostensibly to Genoa. In the middle of the Mediterranean near Crete, two Israeli gunboats seized the freighter and sent the entire shipment to Haifa and thence to Dimona. Eight days later the freighter turned up in Palermo, Sicily, empty with no crew and all evidence erased. The Italian company presumed that the shipment was hijacked by pirates. It is estimated that the stolen cargo contained enough uranium to run a reactor like the one at Dimona for up to a decade and yield plutonium for assembling around thirty atomic bombs. News of this incident, described as "laundering" of Yellowcake due to weak safeguards leaked out in course of time.

Israel was also reported to have entered into a secret agreement with South Africa to provide technical and critical materials assistance in its nuclear weapons programme in exchange for the supply of 300 tons of uranium as well as access to nuclear weapons testing grounds in South Africa. South Africa abandoned its nuclear weapons programme and signed the NPT in 1993. Paul de Klerk, President of South Africa disclosed in 1993 that South Africa built six atom bombs and destroyed them.

From its inception the Israeli nuclear programme was conducted under the strictest secrecy. Israel described the Dimona complex as a textile plant, an agricultural station and a metallurgical research facility till 1960 when David Ben- Gurion announced it as nuclear research centre for peaceful purposes. The US inspectors visited Dimona several times during the 1960s but were unable to obtain an actual picture of the activities due to "tight Israeli control over the timing and agenda of the visits." The Israelis even installed false control room panels and put up brick barriers over the elevators and hallways that accessed the critical areas of the facility. As a result the US inspectors could find no evidence of "weapons related activities" even after visiting Dimona seven times. The US Government is said to have been deliberately kept in the dark by the US diplomatic corps in Israel about the activities in Dimona. Walworth Barbour, the US Ambassador to Israel from 1961 to 1973is believed to have played a crucial role in insulating the US President from receiving intelligence reports on the Israeli programme.

The lid of secrecy of the Israeli weapons programme was finally opened by Mordechi Vanunu, a former Israeli nuclear technician by revealing details of Israel's nuclear weapons programme to London Sunday Times in 1986, complete with photographs of the nuclear weapons facility that lay behind the bricked-over area of the complex. The London Sunday Times, after verifying every detail of Vanunu's story broke the news in its October 5, 1986 issue under the Headline; *'Revealed: The Secrets of Israel's Nuclear Arsenal.'* Vanunu was arrested by the Mossad in Rome. After spending 18 years (including solitary confinement for 11 years) in jail he was set free in 2004 only to be put back in jail several times on charges of violations of restrictions.

Israel has never made public the details of its nuclear weapons inventory. According to 2010 estimates, Israel has between 100 and 200 nuclear warheads including 100 thermonuclear devices capable of being delivered by missiles, fighter bombers or submarines.

There is no evidence that Israel has ever carried out a nuclear test. But there is speculation that a suspected nuclear explosion in the Southern Indian Ocean on September 22, 1979 was a joint Israeli-South African nuclear test. Analysis of a distinctive flash recorded by the US "Vela" satellite together with other information from intelligence sources gave strong evidence that the flash has been caused by a low-yield nuclear explosion.

Israel's security fears and its decision to go nuclear can be understood in the context of the Israeli raid and destruction Iraq's nuclear reactor on June 7, 1981. Iraq bought a 40 MW light water nuclear reactor from France in 1976. This Osiris-class reactor fueled with approximately 12.5 kilograms of enriched uranium and intended for peaceful purposes was named Osirak by the French, blending the names of Osiris and Iraq. The Israeli Government apprehended that Iraq had intentions to develop nuclear weapons at the Osirak reactor. Failing in its intense diplomatic efforts to halt the French Government financing the project, Israel decided to launch a military strike before the reactor was loaded with nuclear material and thus avoid the danger of nuclear fallout. Taking off from the Negev Air Force base on June 7, 1981, a squadron of fourteen Israeli planes headed to Iraq flying through the Jordanian and Saudi airspace. King Hussain of Jordan, who was vacationing in Aqaba at the time, saw the planes pass over his head. He immediately notified the Iraqis of the danger of their country being the target. The Iraqis never got the message due to communication errors and were caught completely by surprise. The reactor was reduced to rubble in one minute and twenty seconds! It is the world's first air strike against a nuclear plant.

In a similar manner Israel, in an operation called Operation Orchard, destroyed on September 5, 2007, Syria's nuclear reactor near al-Kibar. Israel never publicly claimed credit for the strike, and Syria never acknowledged that its reactor was destroyed!

Two weeks after the Osirak attack, Israel admitted it had the capability of developing its own nuclear weapons. However it is yet to declare itself as a nuclear weapons state!

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India Becomes a Nuclear Weapons State

India's nuclear energy programme began just eleven days after the country achieved independence with the creation of the Board of Research on Atomic Energy by the Council of Scientific and Industrial Research, with Homi J. Bhabha as its Chairman. Bhabha, who already achieved international recognition through his research contributions in the field of elementary particle physics and cosmic rays, was a man of vision going beyond the limits of pure research into the realm of technological and industrial development. He dreamt of a modern technologically self-reliant India.

After holding discussions with reputed scientists abroad with whom he was closely associated, Bhabha presented to Prime Minister Nehru in April 1948, a programme for the organization of nuclear research in India. Prime Minister Nehru acting promptly got the Atomic Energy Act 1948 passed by the Parliament and constituting the Atomic Energy Commission with Bhabha as its Chairman. While piloting the Act in the Parliament Prime Minister Nehru declared," We must develop atomic energy quite apart from war - indeed I think we must develop it for the purpose using for peaceful purposes...... Of course, if we are compelled as a nation to use it for other purposes, probably no pious sentiments of any of us will stop the nation from using it that way."

The Atomic Energy Commission, functioning directly under the Prime Minister, was given powers to find, create and operate all facilities, from mineral exploration to technological research and development, for the atomic energy programme. A Research Centre was established in 1954 at Trombay, Bombay, with Bhabha as its Director. Originally called the Atomic Energy Research Establishment Trombay (AEET), the Centre was later named the Bhabha Atomic Research Centre (BARC) in memory of Bhabha who was killed in an air crash in 1966.

The first major achievement of the Research Centre was the building of a swimming pool-type nuclear reactor, APSARA, in 1956, the first in Asia outside the Soviet Union. Except for the fuel elements which were procured from the UK, the reactor with all its equipment was built by the Indian scientific and technical personnel. M.R. Srinivasan, Ex-Chairman, AEC, who was closely associated with building the reactor recollects (DNA, August 6, 2005), "The Chinese Premier Chou En-Lai visited APSARA at the time when China did not have a reactor of its own. En-Lai did not betray any emotions. He looked like a smiling Buddha to me." This smiling Buddha went back to China and accelerated the country's nuclear programme leading to the successful explosion of its first atom bomb on October 14, 1964. It was ten years (May 18, 1974) later that India exploded its first nuclear weapon under the project codenamed SMILING BUDDHA! H.N. Sethna, another Ex-Chairman even doubted the wisdom of taking Chou En-Lai on a visit to the Atomic Energy Establishment. To quote him, "When Chou En-Lai visited us, Dr. Bhabha showed him an ingot of Uranium wieing 50 Kg. and asked him to try lifting it. He (Chou) told us that we were ten years ahead of them, but he went back and within two years, China exploded the atomic bomb with the Uranium they produced by taking technical help from Russia. On hindsight, it was not right for us to show off our capacity to him." (Physics News, January 2009).

APSARA was followed by the building of CIRUS (Canadian-Indian Reactor, US), a 40 MW natural uranium heavy water moderated research reactor in 1955, under Atoms for Peace programme with Canadian assistance. The heavy water required was supplied by the US. The close association of the Indian scientific personnel with the Canadian engineers in all stages of this exercise helped the Indian personnel acquire advanced nuclear technological expertise. As the agreement between Canada and India was signed before the IAEA safeguards came into force, there was no clause for accounting for plutonium the CIRUS reactor has produced. But Canada received assurances from India that "the reactor would be used only for peaceful purposes." Taking advantage of the absence of safeguards India built a plutonium plant at Trombay, known as Project Phoenix, to process the uranium fuel discharged from the CIRUS reactor. The plant had a capacity to process 20 tonnes of fuel per year. Construction of this plant designed by the Indian scientists began in 1961. With its commissioning in 1964, India became the fifth country (UK, US, France and USSR were the other countries) with capability to reprocess and recover plutonium from spent nuclear fuel. The 100 MW DHRUVA reactor, a larger version of CIRUS built entirely with Indian expertise, became operational in 1985.

Beginning 1959, disputes cropped up between India and China over the demarcation of the 3,225 km long Himalayan border. These disputes as well as other disputes led to the Sino-Indian war in 1962. Also by 1961 India became aware of China's nuclear programme. These events led to India taking greater interest in developing its nuclear capability. In a statement in the Parliament on January 8, 1961 Prime Minister Nehru declared, "We are approaching a stage when it is possible for us ..... to make atomic weapons." A committee was constituted in 1962 for developing an implosion-type nuclear device using the plutonium recovered from the spent fuel of the CIRUS reactor.

Major General Nichols Kenneth D. Nichols of US narrates an incident when Bhabha and he met Nehru in 1960. Nehru asked Bhabha, "Can you develop an atomic bomb?" Bhabha assured he could and said that he would need about a year to do it. Nehru then turned to Nichols and asked him whether he agreed with Bhabha. Nichols replied that he knew of no reason why Bhabha could not do it. “He had men who were as qualified or more qualified than our young scientists were fifteen years earlier.” Nehru then turned to Bhabha and said,”Well don’t do it until I tell you to.”

In September 1962, the Government of India amended the Atomic Energy Act on the lines of the US Atomic Energy (McMahon) Act of 1954, giving the Government of India strict control over all decisions on atomic energy and powers for enforcing secrecy through linking atomic energy and its control to national security.

Lal Bahadur Shastri succeeded Nehru as the Prime Minister in June 1964. A Gandhian, PM Shastri was opposed to the nuclear weapons programme. But Bhabha began openly lobbying for political and public support for the bomb. He even declared that India could assemble a bomb within 18 months of the Government’s favorable decision.

The anticipated Chinese nuclear test was conducted on October 14, 1964. Even in the face of PM Shastri’s opposition to pursue nuclear capability, Bhabha in a radio talk on October 24, 1964 declared that the “ atomic weapons give a State possessing them in adequate numbers a deterrent power against attack from a much stronger State.” A debate in India’s Parliament also saw its members pleading, cutting across party lines, for the development of an atomic bomb. In response Shastri authorized in April 1965 the development of nuclear explosives with the caveat that they should only be used for peaceful purposes such as tunneling through mountains. Bhabha set up a group under Raja Ramanna for a Study of Nuclear Explosives for Peaceful Purposes (SNEPP). The choice of a Peaceful Nuclear Explosive (PNE) test was considered consistent with India’s declared opposition to nuclear weapons and also the hope that it “would not jeopardize the international assistance that was still needed for the programme.” Further, a PNE test is in conformity with Article V of the

NPT which says that "under appropriate international observation and through appropriate international procedures, potential benefits from any peaceful applications of nuclear explosions will be made available to Non Nuclear Weapon State Party to the Treaty...." There were reports that Bhabha, during one of his visits to the US during this period, scouted for assistance in building nuclear explosives for such purpose.

Bhabha died in an air crash on January 24, 1966. A few days earlier, PM Shastri died of a heart attack on January11. Indira Gandhi who succeeded him as the Prime Minister chose Vikram Sarabhai as the Chairman of the Atomic Energy Commission. Sarabhai, who was opposed to nuclear weapons, ordered a halt to SNEPP. However the group constituted by Bhabha went ahead with the task of preparing the groundwork for the PNE experiment.

There was an important development during this period at the international level. The nuclear powers decided to evolve a non-proliferation regime through an international treaty (NPT). India demanded that such a treaty should obligate the existing nuclear weapon states to freeze and then eliminate their nuclear arsenals and also provide security guarantees to states that do not have nuclear weapons. While expressing strong opposition to nuclear weapons, India refused to surrender its right to develop and test the nuclear explosives as the nuclear 'haves' retained such rights. India continues to stick to this stand.

By 1969, Indira Gandhi consolidated her hold on the party and the Government. Sarabhai, Chairman of AEC passed away suddenly in 1971. He was succeeded by H.N. Sethna, the architect of the Plutonium Plant at Trombay. The India-Pakistan war that erupted in 1971 resulted in the creation of Bangladesh. During this war the US tried to bully India by sending its nuclear powered aircraft carrier

Enterprise into the Bay of Bengal. These developments as well as China's nuclear capability created security concerns for India. In September 1972 Indira Gandhi authorized Sethna to go ahead with the PNE test. In the words of Sethna,"...... and that is when she handed over the Plutonium Plant to me and said go ahead and do what you want to do. But I want a device to shake the world." (Physics News, January 2009).

India's PNE test was conducted successfully at Pokhran, a few dozen miles from the India-Pakistan border on May 18, 1974. The explosive power was put at *between* 12 and 15 kilotons TNT. Subsequent reports described the yield as 12 kilotons. The value has been further scaled down by the US experts to 4 to 6 kilotons. The Pokhran PNE test thus became the first confirmed nuclear test by a nation that was *not* a permanent member of the UN Security Council.

The test, which was conducted under utmost secrecy, was taken seriously by Canada, US and UK. Punitive action was taken by these countries by stopping all assistance to India in its nuclear programmes such as power reactor construction as well as nuclear fuel and heavy water supplies. India was also denied supplies of all nuclear related materials and equipment from foreign suppliers through cartelization (e.g. Nuclear Suppliers Group). As a result there was a serious setback to India's entire nuclear energy programme. But this proved a blessing by helping the Indian scientific and technical personnel gaining valuable expertise in nuclear technology through indigenous efforts.

Beginning 1975 the Indian political system went through a series of upheavals. Indira Gandhi lost power in 1977 and Morarji Desai, who was opposed to India securing nuclear capability, became the Prime Minister. He even announced at the UN General Assembly that India would not conduct any nuclear 'explosion'. Ramanna who was heading the NPE project was moved out of the BARC. At this point intelligence reports revealed that A.Q. Khan began pursuing Pakistan's uranium enrichment programme. There upon India's Cabinet Sub Committee by a majority 3-2 vote decided to activate its weapons programme. The two members who opposed the move were believed to be Desai and more surprisingly, Atal Behari Vajpayee, Indira Gandhi came back to power in 1980. With Pakistan's quest for nuclear weapons picking up tempo, Ramanna was brought back to accelerate the Indian effort. After Indira Gandhi's assassination in 1984, her son Rajiv Gandhi succeeded her. Rajiv Gandhi, who was averse to nuclear weapons, was more interested in pursuing the policy of total nuclear disarmament. In 1988, he placed before the UN Assembly his nuclear disarmament plans, which received only lukewarm response. Earlier in 1987 during Operation Brasstacks undertaken by India, A.Q. Khan, in an interview given to Kuldip Nayyar, stated, "You people be careful, we have the bomb." In the face of such increasing nuclear threat from Pakistan Rajiv Gandhi changed his mind and permitted the development of deliverable nuclear weapons. Rajiv Gandhi lost elections in 1989 and was succeeded by V.P. Singh. He also faced similar warning from S. Ayub Khan, Pakistan's Foreign Minister.

Rajiv Gandhi was assassinated during the mid-term election campaign in 1991. P.V. Narasimha Rao who became Prime Minister paid greater attention to economic reforms. At the same time he supported the nuclear weapons programme. In 1995, the NPT was extended indefinitely though India was opposed to the Treaty (for reasons already indicated). Narasimha Rao realized that if India's strategic security interests are to be protected, expeditious action should be taken to forestall enormous international pressure on India to sign the NPT. The only way this could be done was to adopt the policies of realpolitik as practised by the West as well as China. Narasimha Rao ordered conducting a nuclear test. But the preparations underway were tracked by US through satellites. Under pressure from the US India had to stop the test. Narasimha Rao was succeeded by Vajpayee as the Prime Minister in 1996. Narasimha Rao is reported to have written a letter to Vajpayee saying, "I could not do it, you do it." According to K. Subramaniam, India's respected strategy expert, Vajpayee himself revealed this after Narasimha Rao's death in December 2004. A.P.J. Abdul Kalam, former President of India, who as Scientific Advisor to the Defence Minister played a major role in Pokhran II test in 1998, while delivering the 7th R.N. Kao Memorial Lecture organized by the Research and Analysis Wing of the Cabinet Secretariat on January 24, 2013, described how Prime Minister Rao who was relinquishing his office in 1996 in the wake of his party's defeat in the elections, called Atal Behari Vajpayee, the PM designate, and briefed him in Kalam's presence on the test plans and thus enabled a smooth takeover of the nuclear programme. Kalam praised Rao for this act which "reveals the maturity and professional excellence of a patriotic statesman who believed that the nation is bigger than the political system".

But Vajpayee's government lasted only a short period. Deve Gowda and Gujral succeeded Vajpayee one after the other. The programmes covering nuclear weapons and the delivery systems continued during their tenures. Gujral, when he met US President Clinton in September 1997 during the UN General Assembly euphemistically indicated India's nuclear weapons quest. He recounts telling Clinton that an old Indian saying holds that Indians have a third eye. " I told President Clinton that when my third eye looks at the door of Security Council Chamber it sees a little sign that says ' *only those with economic power or nuclear weapons allowed'*, I said '*it is very difficult to achieve economic wealth'*."

In October 1997, Ramanna declared in a meeting,"The

Pokhran test (PNE test) was a bomb." (Associated Press, Oct.10, 1997).

The BJP came back to power after the midterm elections in 1998. On March 18, 1998, a day before assuming charge as Prime Minister, Vajpayee declared, "There is no compromise on national security. We will ensure all options including nuclear option to protect security and sovereignty." Arrangements for the tests at Pokhran, under the codename Operation Shakti, followed. Tests were conducted in two groups. The first , conducted on May 11, consisted of a thermonuclear weapon Shakti I with a yield of 43 kilo tonnes, a light compact tactical fission weapon Shakti II with a yield of 12 kilo tonnes, and a tactical fission weapon Shakti III with a yield of 0.2 kilo tonne. Two days later Shakti IV and V with yields of 0.2 and 0.3 kilo tonne were tested. As against the Indian claims of a combined yield of 55 kilo tonnes the US and other reports arrived at values ranging from 12 to 25 kilo tonnes. With these tests India has come to be recognized as a nuclear power. In this context it is interesting to recall the prophetic words of Nani A. Palkhivala, the great Indian legal luminary. In his Jawaharlal Memorial lecture delivered at the Trinity College, Cambridge on November 7, 1990, he said, "It (India) even exploded an atomic device (1974) - our only one- and learnt the bitter lesson that one explosion activates international reaction. But a series of explosions anaesthetizes it. One blast brings discredit while a sequence brings prestige and power."

After India's tests, Gohar Ayub Khan, Pakistan's Foreign Minister declared, "We in Pakistan will maintain balance with India ..... in all fields. We are in a headlong arms race on the sub-continent." A few days later on May 28, Prime Minister Nawaz Sherif announced that Pakistan detonated five nuclear weapons.

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Pakistan's Nuclear Walmart

Pakistan's entry into the nuclear arena began with the constitution of the Pakistan Atomic Energy Commission (PAEC) in 1956 to enable the country to participate in the Atoms for Peace programme. The progress was slow till 1960 when Zulfikar Ali Bhutto, Minister for Mineral and Natural Resources began taking active interest in the project by appointing Ishrat H. Usmani as the Chairman of the PAEC. Usmani established the Pakistan Institute of Nuclear Sciences and Technology (PINSTECH) in Nilore, Islamabad Capital Territory, and sent hundreds of young scientists for training abroad. With a grant given by the US, a 5 MW light water research reactor began operating in 1965 at PINSTECH. Along with Abdus Salam, the Nobel Laureate Physicist, Usmani played active role in reaching an agreement in 1965 with GE Canada for building the country's first commercial nuclear power plant at Karachi. This 137 MWe plant, operated with heavy water moderated and natural uranium fuelled reactor, was commissioned in 1972. The Canadian Government also provided Pakistan a small heavy water production unit.

Bhutto became Foreign Minister in 1963. But he continued to take active interest in the nuclear programme. By 1964 it became certain that China was on the brink of conducting a nuclear weapon test. Bhabha and some political leaders also began actively lobbying that India should follow suit. Marshal Ayub Khan, Pakistan's President and Bhutto went to Beijing and met Chou En-Lai for support in Pakistan's nuclear quest. Following this visit and the Indo-Pakistan conflict, Bhutto, in mid-1965 bared Pakistan's nuclear ambitions to match India's nuclear capability by declaring, "Pakistan will fight for a thousand years. If India builds the bomb, Pakistan will eat grass, even go hungry, but we will get one of our own. We have no other choice." To put his words into practice Bhutto however had to wait till 1972 when he became Prime Minister after Pakistan's crushing defeat in the Indo-Pak War, which led to the break-up of Pakistan and creation of Bangladesh. Shortly after assuming power Bhutto convened a meeting of scientists on January 24, 1972 at Multan where he explained his keenness to pursue the nuclear weapons project. Abdus Salam, who was actively associated with the organization of the PAEC, did not appear favourable to the project. Usmani, the Chairman of PAEC also did not support on the ground that Pakistan lacked the technology and infrastructure for the programme. Bhutto replaced Usmani with Munir Ahmad Khan as the Chairman. Munir Khan, an alumnus of Argonne National Laboratory (a constituent of the US Manhattan Project) underwent training in several institutions engaged in nuclear technology. In 1958 he joined the IAEA and worked as the Head of the Reactor Engineering and Nuclear Fuel Cycle. In the IAEA circles he was known as the "Reactor Khan". During his stint with the IAEA he used to brief Bhutto and President Ayub Khan on India's nuclear weapons programme. He impressed on Ayub Khan that Pakistan should also acquire nuclear weapons capability. For the next 19 years Munir Khan as the Chairman of the PAEC vigorously pursued Pakistan's nuclear weapons programme.

The primary requirement for nuclear weapons production is the availability of plutonium or enriched uranium. Pakistan initially chose plutonium as the key ingredient to be secured through the processing of the spent nuclear fuel from the Karachi plant. It entered into a contract with British Nuclear Fuels Ltd. for the design and erection at PINSTECH, of a pilot plant for fuel reprocessing with a capacity of separating up to 360g of fuel a year. This was followed by a contract with the French corporation Saint-Gobain Techniques Nouvelles (SGN) for a large-scale reprocessing plant at Chashma, with capability to produce plutonium by reprocessing 100 tons of spent fuel per year.

The contract, which did not include significant safeguards against the diversion of plutonium for weapons use, was aborted in 1979 under US pressure. But with the blue prints already in the hands of the PAEC, the plant construction was reportedly completed later with assistance from China.

Bhutto secured financial support from Libya and Saudi Arabia and Iran for Pakistan's weapons programme. Addressing the Organization of Islamic countries in Lahore in 1974 Bhutto declared that Pakistan's bomb would be an "Islamic bomb" and could be the foundation for Islamic countries acquiring strategic military capacity to counter other nuclear weapons states, thus signaling Pakistan's willingness to supply nuclear materials and know-how to other Islamic states.

India conducted in May 1974 its nuclear test for peaceful purposes. With the consequential imposition of greater restrictions on nuclear exports to all nations, Pakistan too suffered a setback in its efforts to extract plutonium from spent nuclear fuel. It was therefore forced to switch over from plutonium to enriched uranium as the material for its weapons programme. Under the leadership of S. Bashirudddin Mahmoood work began on a pilot plant for uranium enrichment using the centrifuge technique. The PAEC actively began hunting around for equipment and materials for uranium enrichment as well as plutonium reprocessing.

At this stage a new actor, Abdul Qadir Khan, entered the scene. Khan, who was born in Bhopal, immigrated to Pakistan. Educated in Germany and Belgium in metallurgical engineering he joined the Anglo-Dutch-German centrifuge partnership company URENCO in 1972. In 1974 he wrote to Bhutto expressing his keenness to work for Pakistan. In December 1975 he left suddenly for Pakistan taking with him copied blue prints of centrifuges and other technical details as well as a list of 100 companies that supplied the centrifuge parts and materials and joined PAEC. After a brief stint in the PAEC he moved to Kahuta where, within two years, he assembled a working prototype of centrifuge for enrichment of uranium. He replaced Bashiruddin Mahmood as the Director of the enrichment project, which was renamed as Engineering Research Laboratories (ERL). By 1978 the ERL succeeded in producing Highly Enriched Uranium (HEU). General Zia-ul-Haq who by then became Pakistan's military ruler, renamed in 1981 the ERL at Kahuta as Khan Research Laboratories in recognition of Khan's contributions to the development of the project. A Dutch court convicted Khan in 1983 and sentenced him to four years in prison on charges of nuclear espionage. But on appeal the sentence was overturned on technical grounds.

The Kahuta enrichment plant, which employed 7,000 people including 2,000 scientists, achieved its full production level in 1986 with a production capacity of 45-100 kg of HEU per year, enough for 3 to 7 nuclear weapons. By 1992, Kahuta unit was believed to have operated about 3,000 centrifuges. Currently their number is reported to have increased considerably. A second enrichment plant was built at Golra. Pakistan's current production of HEU is put at 110 kg per year. By the end of 2000 Pakistan is believed to have produced 800 kg of HEU (excluding the quantity used for the 1998 tests) enough for about 50 nuclear weapons.

Khan was able to achieve this task in a short time, by taking advantage of his "long stay in Europe and intimate knowledge of various countries and their manufacturing firms." According to Khan, "The European firms were eager to do business with us. They literally begged us to buy their equipment." He further boasted "A country which could not make sewing needles was embarking on one of the most difficult technologies. We devised a strategy whereby we go all out to buy everything that we needed in the open market." The ploys adopted to circumvent the nuclear export control regimes of various states included

Use of Pakistan embassies abroad,

Paying above market prices,

Keeping one step ahead of export controls,

Hiding a critical component in a long list of useless material,

Buying a sample s well as the method to reproduce it,

Using multiple connections and buyers to look for a given item,

Using front companies,

Falsifying the end user,

Using multiple intermediaries,

Enlisting the help of friendly countries,

Taking the help of Pakistani-born foreign nationals, and Capitalizing personal connections.

While the enrichment route became the visible part of its weapons quest, Pakistan also directed its efforts to activate its plutonium strategy, which earlier suffered a setback after Germany cancelled its contract for a heavy water production plant; Canada stopped supply of nuclear fuel and the French firm St. Gobain withdrew from the construction of the reprocessing plant at Chashma. But the activity was revived in 80s with the commissioning of a heavy water facility supplied by Belgium, and the completion of the pilot plant for plutonium reprocessing at PINSTECH with China's help. This period also saw the signing of a civilian nuclear cooperation agreement between China and Pakistan. A heavy water-moderated 50MW reactor with capacity to produce about 10-15 kg of plutonium per year and tritium (for hydrogen bomb), an additional reactor and heavy water facility were built at Khushab with Chinese assistance. With the commissioning of the reprocessing plant at Chashma, Pakistan was able to significantly increase its plutonium production for weapons.

As early as 1974 the PAEC initiated the programme of developing the design for a plutonium-based nuclear weapon. The first successful cold test of a nuclear device without nuclear fuel was conducted in 1983. A second test followed soon after. A nuclear weapon design small enough to be carried by aircraft was developed and tested in 1987. It is believed that a China conducted a nuclear weapon test for Pakistan at its Lop Nor test site on May 26, 1990. Nawaz Sharif, Prime Minister of Pakistan addressing a political rally said, "Let me tell you that we (Pakistan) have atomic bombs…… Pakistan's nuclear capability is now an established fact. Whatever we have, we have a right to keep it." Following the five underground nuclear test carried out by India on May 11 and 13, 1998, Pakistan carried out an equal number of tests at the Chaghi nuclear test site on May 28 and a sixth test on May 30, 1998. Pakistan's Foreign Office termed it as "Pakistan's Finest Hour."Announcing the May 28 tests Prime Minister Nawaz Sharif declared, "Today we have settled a score and have carried out five successful nuclear tests." The PAEC claimed that the five tests on May 28 had a yield of up to 40 kilotons while the sixth test on May 30 had a yield of 12 kilotons. But American reports indicated lower yields of 9-12 and 4-6 kilotons respectively.

Apart from the geopolitical issues arising from Pakistan's nuclear capability, a matter of great concern has been the nuclear proliferation activities pursued by A Q Khan. Ever since he joined the PAEC Khan, with the impressive progress achieved under his leadership, enjoyed a remarkable degree of power and autonomy under successive heads of state, especially President Zia. Buoyed up by the approbation that followed, Khan turned into an undercover salesman of uranium and enrichment equipment to a number of countries, which included China, North Korea, Iran, Libya and possibly Iraq. He began ordering twice the number of components necessary for the Pakistani programme and sold the surplus to several countries through his network. Offices were opened in East Africa for buying uranium from Niger. Designs and technology for centrifuges for uranium enrichment were provided to Iran as well as training to Iranian scientists. Agreement was entered into with North Korea for missile cooperation in exchange for enrichment technology. A centralized "one stop shop", dubbed as "Nuclear Walmart", was set up at Dubai under the name Gulf Technical Industries that offered technical advice, parts and customer support. The Khan Research Laboratories even had brought out "coloured brochures advertising centrifuges and other components" for the prospective clients. In October 2003 a German ship heading to Gaddafi's Libya was caught carrying a clandestine consignment of centrifuges manufactured at Khan's initiative by a company in Malaysia with financial assistance of a Sri Lankan Muslim, B S A Tahir. Following this incident Libya gave up all nuclear related activities. There were also reports of "stunning degree of proliferation between Islamabad and Beijing." Jim Walsh, Director of the Atom Project at Harvard's Kennedy School of Government observed,"Pakistan is absolutely the biggest and the most important illicit exporter of nuclear technology in the history of nuclear age."

All this activity would not have been possible without the complicity of Pakistan's bureaucracy and military. Pakistan however insisted that proliferation was a rogue operation by Khan and the government or military had nothing to do with it. Interestingly Khan on one occasion disclosed that General Jehagir Karamat (Chief of Army Staff, 1996-88 and Ambassador to US, 2004-06) "took US $ three million through me from the North Koreans and asked me to give them some drawings and machines." The US, which also knew about these clandestine activities preferred to close its eyes on geopolitical considerations in the wake of the Soviet invasion of Afghanistan in 1979.

The New York Twin Tower destruction in September 2001 however proved Khan's Nemesis. Under pressure from the US, President Musharraf stripped Khan of all responsibilities. Fearing further harassment to self and family, Khan, in a letter of December 2003, asked his Dutch wife Hendrina to take a "tough stand "if the Pakistani Establishment played any mischief with him." He also wrote, "The bastards first used us and are now playing dirty games with us." Pakistani intelligence got wind of this letter and forced him to appear over TV on February 5, 2004 and publicly take the blame for the proliferation activities. President Musharraf extended official pardon to Khan and sent him into retirement. The Time Magazine in its Feb 14, 2005 issue described Khan as "The Merchant of Menace." According to some sources though Khan has been removed from the Khan Research Laboratories, his illicit network of suppliers and middlemen which is global in scope is still believed to be active.

Khan retracted on his February 5, 2004 confession and said that he was pressurized to acknowledge that he had run a proliferation network. In an On Line interview to SPIEGEL on June 28, 2012 he said, "I feel stabbed in the back by the very people who benefitted most from my work, i.e. the Army." He further said, "I still believe that I did Pakistan a favour. Nuclear weapons are a means of ensuring peace by using as a tit-a-tat. I am convinced that there will never be another war between India and Pakistan as a consequence thereof." In another interview he gave in September 2012, Khan claimed that he had transferred nuclear technology to "two countries" on the orders of the then Prime Minister Benazir Bhutto. Though he did not name the two countries they are believed to be Libya and North Korea.

The most disturbing aspect is the control and safety of Pakistan's nuclear arsenal. In theory the Prime Minister of Pakistan, as the Chairman of Nuclear Command Authority, handles the Command and Control of the country's nuclear arsenal and related organizations, but it is Pakistan's Islamized army top brass which has the final say about employing the nuclear option.

The Atlantic Journal in an article *The Ally from Hell* (December 2011) observed, "Pakistan, an unstable and violent country located in the epicenter of Global Jihad, might not be the safest place on earth to warehouse hundred plus nuclear weapons." There have been terrorist attacks on Pakistan's military establishments, especially with insider support. Some military establishments targeted include Army General Headquarters (October 2009), Naval Base at Mehran (May 2011) and Air Base at Kamra (August 2012). It is feared that through such tactics terrorist groups could gain direct access to nuclear storage bunkers with serious consequences. A Washington Post report (TOI, September 4, 2013) says that the US has ramped up its surveillance of Pakistan's nuclear weapons.

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North Korea's On-Off and On-Off Nuclear Quest

The Korean Peninsula was part of the Japanese empire till the end of World War II. After the surrender of Japan in August 1945 the Peninsula was carved into two occupation zones with the zone north of the 38th parallel coming under Soviet control and the zone south of the parallel coming under American control. Ultimately these two zones evolved into two independent nations with diametrically opposite political, economic and social systems. The north became the Democratic People's Republic of Korea (DPRK), a highly centralized communist country under the Soviet hegemony while the south became the Republic of South Korea with American support. With the object of reunifying the Peninsula, DPRK invaded South Korea in 1950. The Soviet Union however did not support this adventure. But with the Chinese forces of the People's Republic of China joining the DPRK forces the venture developed into a full-fledged war between the invading forces and the UN forces under General Douglas McArthur defending South Korea. The US seriously considered a tactical use of atomic weapons to block the passages leading from Manchuria and Vladivostok and halt the Chinese and possibly the Soviet forces entering North Korea. Though by this time the Soviet Union also acquired nuclear weapons, "Washington was not worried because the US possessed at least 450 bombs and the Soviets only 25." This idea did not however meet the approval of the US Joint Chiefs of Staff because the targets were not large enough to warrant their use. There was also concern about adverse world opinion if another Asian country became the target of nuclear weapons after Japan's Hiroshima and Nagasaki. In an interview published posthumously in the New York Times (April 9, 1964) General McArthur said that he had a plan that would have won the Korean War in 10 days. "I would have dropped 30 or so atom bombs …… strung across the neck of Manchuria. My plan was a cinch." The Korean War however came to an end in July 1953 with no such use of nuclear weapons.

The Korean War was followed by the Mutual Defence Treaty between the US and South Korea in 1953. The Cuban Missile Crisis in 1962 brought the world closest to a nuclear war. These incidents spurred North Korea's dictator Kim Il-Sung to launch the country's own nuclear weapons project. Launched in 1960 this project received technical and material assistance from Soviet Union and China during the following decades. A Nuclear Scientific Research Centre established at Yongbyon was manned by North Korean scientists trained in the Soviet Union. A 5MW nuclear reactor for power production was commissioned in 1986 at Yongbyon after seven years of construction with Soviet help. Endowed with uranium mines containing four million tons of high quality ore, North Korea also began focusing attention on uranium ore refining, conversion and fabrication of nuclear fuel. While the reactor construction was in progress North Korea joined the IAEA for ferreting out crucial technical information on nuclear weapons. A nuclear scientist was stationed at the IAEA at Geneva for the purpose. North Korea also signed the NPT in 1985. Though it initially declined to sign the IAEA safeguards agreement unless the threat from US nuclear forces in South Korea is removed, North Korea signed this agreement in 1992. Steps were initiated for the construction of two nuclear reactors with 50 MW and 200 MW power output. But these programmes were given up in 1994.

With an eye on nuclear weapons production, North Korea used its nuclear reactor at Yongbyon mostly for the production of weapons grade plutonium and not for power production. It is reported that ever since it was in operation the reactor has generated electric power for only 23 days. Rest of the time the reactor was operated for productions of weapons-grade plutonium. Intelligence reports estimate that about 6 to 13 kilograms of weapons-grade plutonium was separated and kept away. In August 1993, North Korea agreed to resume discussions with IAEA and allowed IAEA inspectors into Yongbyon to service its safeguards monitoring equipment. But access to the reprocessing facilities was denied to them. When the IAEA requested compliance with their safeguards obligations, North Korea announced in 1993 its intention to withdraw from the NPT. After the departure of the IAEA inspection team, North Korea officially withdrew from the IAEA in June 1994. Meanwhile during the spring of 1994, North Korea was reported to have unloaded fuel elements containing about 25±8 kilograms of plutonium from its Yongbyon reactor. By mid-2006, North Korea is believed to have produced about 43-61 kilograms of plutonium. Out of this about 20 to 53 kilograms are separated in a state of purity suitable for weapons production. Kim Jong - II succeeded his father in 1994 as the ruler of North Korea.

North Korea also initiated uranium enrichment programme to supplement its nuclear weapons capability. Pakistan, using A Q Khan as an intermediary, played a significant role in this programme by supplying in 1990 uranium enrichment equipment and perhaps even nuclear warhead designs in exchange for missile technology. Evidence for this deal is provided by a letter dated July 15, 1998 from Jon Byong Ho, Secretary of the Workers Party of Korea, DPRK, to A Q Khan which reads,".....General Kong told me that three million dollars have already been paid to the Army Chief General J. Karamat and half a million dollars and three diamond and ruby sets to General Zulfiqar Khan. Please give the agreed documents, components etc. to Mr. Yon to be flown back when our plane returns after delivery of missile components. Excellency please be accepting our heartfelt felicitations on the recent success of your nuclear tests. It was only possible because of your hard work and team effort."

The years following 1994 saw an improvement in the relations between the US and North Korea with the former agreeing through the "Geneva Agreed Framework" to help North Korea get over its energy and economic crisis by supplying fuel oil, extending economic cooperation and building two light water nuclear power plants with Japan and South Korea also participating in the venture. North Korea agreed to eventually dismantle its outmoded Yongbyon nuclear reactor and allow its spent fuel taken out of the country. In August 1998 North Korea launched its Taepodong-1 missile which flew over Japan. This led to Japan withdrawing its aid to build North Korea's two light water reactors.

The assumption of Bush as US President and the September 11, 2001 terrorist attacks of the New York Twin Towers saw a further setback in the US-North Korea relations. Bush indicted North Korea as part of an "Axis of Evil". North Korea responded with reactivation of its nuclear weapons programme. In January 2003, North Korea announced its decision to withdraw from the NPT stating, "A grave situation has been created today in our country, which threatens its national sovereignty and security of our state........ due to the vicious policy towards DPRK". North Korea, the only country to withdraw from the NPT, also announced the cancellation of the Geneva Agreed Framework. In August 2004 North Korea described President Bush an "imbecile" and a "tyrant that puts Hitler in shade". President Bush countered by calling Kim Jong-il "a tyrant".

In February 2005 North Korea claimed for the first time that it possessed a nuclear weapon. This was followed by its first underground nuclear test near Kichlu on October 9, 2006. Seismological results indicated that the yield was low in the 800 ton – 1.2 kilo ton range. Some reports even considered that the test was a fizz.

The explosion event caused renewed diplomatic initiatives to persuade North Korea to abandon its nuclear weapons programme. In February 2007 a six party negotiation exercise involving US, Russia, China, Japan, South and North Korea resulted in an agreement under which North Korea will shut down the Yongbyon nuclear facility and offer its nuclear facilities to the IAEA inspection, and in return the five parties will provide economic and fuel aid to North Korea.

But the talks were stalled in September 2008 with North Korea beginning to restore its facilities at Yangbyon on the ground that the US was delaying removing North Korea from its list of sponsors of terrorism. The following month US took North Korea off the terror list and North Korea agreed to disable the nuclear facilities and allow inspection by IAEA. With the departure of Bush in early 2009 the six nation talks collapsed and North Korea revived nuclear fuel reprocessing activity as shown by satellite surveillance.

In April 2009 North Korea launched a long range rocket thus demonstrating its capability to strike long range targets using nuclear warheads. The UN condemned this act and imposed sanctions on North Korea. A second underground nuclear test was conducted by North Korea on May 25, 2009 at an unspecified place. The communiqué claimed the test "as part of the measures to bolster up its nuclear deterrent for self-defence in every way as requested by its scientists and technicians." The yield was put in the 5-10 kilo ton range. After testing more missiles North Korea declared that "it is fully ready for battle against the US." This led to the UN imposing further sanctions on North Korea.

Kim Jong-il died in December 2011. He was succeeded by his young son Kim Jong-Un. In February 2012 North Korea announced a moratorium on nuclear and long range missile tests for a food aid deal with US. To mark the hundredth birth anniversary of Kim Il-Sung in April 2012 North Korea launched a rocket with the idea of developing an ICBM which could one day carry a nuclear warhead. But the test flopped. The US stopped its food aid. It was also reported that North Korea revived the construction of a nuclear reactor for production of plutonium.

North Korea's programme of producing enriched uranium at Yangbyon with the technology supplied by Pakistan also made significant progress. Siegfried Hecker, a Professor at Stanford who earlier worked at Los Alamos Laboratory, after his visit to Yangbyon in 2008 observed that the enrichment facility was "astonishingly modern" and would "fit into any modern American facility". The officials told Hecker that the facility contained 2,000 centrifuges designed to manufacture only low enriched uranium for civilian purposes. But Hecker was of the opinion that the centrifuges could be easily converted to produce highly enriched uranium for bomb production. Joshua Pollack of US Government and Scott Kemp of MIT recently concluded that North Korea could make much of this specialised enrichment equipment on its own.

North Korea conducted its third nuclear test on February 12, 2013. This device which had a greater yield than the earlier plutonium devices, is believed to have been assembled using Highly Enriched Uranium. The detonation is followed by North Korean threats to attack Guam, Okinawa, Hawaii and the US mainland itself. This gave rise to the belief that North Korea has miniaturized its nuclear device small enough to fit it on its medium and long range missiles.

Observers fear that North Korea's nuclear weapon capability coupled with its missile technology could prove a threat to peace and stability in North-East Asia.

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Brakes on Iran's Nuclear Ambitions?

Iran's nuclear activity began with the signing of an agreement with the US in 1957 for civilian nuclear cooperation under the Atoms for Peace Programme. The following year Iran joined the IAEA. In 1967 the Atomic Energy Organization of Iran built the Nuclear Research Centre at Tehran. A small research reactor with uranium fuel and technical help provided by the US was located at this centre. Iran also joined the NPT in 1968. Under the rule of the Shah, Iran drew up plans, with US backing, for constructing 20 nuclear power plants across the country. Agreements were also entered into with several western companies for the purpose. A subsidiary of the German company Siemens began construction of the power plant at Bushehr in 1974. This year also saw the promulgation of the Atomic Energy Act of Iran for using atomic energy in industry, agriculture, power production, water desalination and other purposes. But Iran's nuclear projects including the construction of the Bushehr reactor were stalled with the withdrawal of Western assistance in the wake of the 1979 Revolution. With Chinese aid Iran however opened a nuclear research centre at Isfahan 1982 and also began plans to build a nuclear reactor using its domestic uranium resources.

The devastating 1980-88 Iran-Iraq War and the growing evidence of an Iraqi nuclear programme motivated Iran to galvanize its nuclear exercise. Iran signed in 1990-93 an agreement with Soviet Union for the completion of the Bushehr Nuclear plant under IAEA safeguards. It also entered into an agreement with China in 1990 to build a facility for uranium enrichment. But China withdrew from the contract under US pressure. The technical support being extended by Soviet companies for the construction of a heavy water reactor at Arak (for plutonium production) was also stalled under pressure from the US.

Following the 9/11 terrorist attack, George Bush in his 2002 State of the Union address called Iraq, North Korea and Iran as the 'Axis of Evil' and accused these governments of threatening the peace of the world through helping terrorism and seeking weapons of mass destruction.

Iran pursued the uranium enrichment programme using the gas centrifuge technique at its secret underground facility at Nataz and Arak. The sensitive designs for gas centrifuges were provided surreptitiously by A Q Khan and his associates. Starting with 160 centrifuges in 2003, the Nataz plant reportedly had about 7,000 gas centrifuges in 2013. Iran is believed to have produced approximately 2,400 kg of 3.5 per cent enriched uranium as of May 2010 and 17 kg of 17.95 per cent enriched uranium as of June 2010. Experts say that this uranium could be converted to highly enriched bomb-grade uranium in roughly ten weeks if fed into 4,000 centrifuges! Though Iran claims that its nuclear programme is purely for peaceful purposes, the IAEA believed that Iran has sufficient technical knowledge to design and assemble an atomic explosion device using highly enriched uranium. An IAEA report of February 2012 says that Iran has significantly stepped up its uranium enrichment programme and expressed its serious concerns about its potential military uses.

Experts differed on Iran's intentions. But the US and Israel took several measures to stall Iran's nuclear activity. In 2010 the US and Israeli governments developed the malicious Stuxnet software and launched a cyber attack on the Nataz plant destroying nearly 1,000 centrifuges, nearly a fifth of those operating at the time. But the production activity recovered soon. Ironically the US itself became the target of a cyber warfare causing chaos and widespread damage to air-traffic control systems, electrical grids and financial markets! The US also imposed economic sanctions on Iran. A report in the New York Times says that five Iranian nuclear scientists were assassinated in the past five years by the operatives employed by Mossad, Israel's intelligence agency.

In April 2012 the IAEA reported that Iran has installed the centrifuges needed for production of enriched nuclear fuel at a deep underground site under mountain near Qum. Drawing a "red line" through a cartoonish diagram of a bomb, representing the point at which Iran has enough enriched uranium to quickly assemble a bomb, Israel's Prime Minister expressed the country's readiness for a lone strike on Iran (as was done in the case of Iraq) to remove "the threat of nuclear weapons in Iran's hands", saying that Israel has "different vulnerabilities and different capabilities". He further declared, "We have to make our own calculation, when we lose the capacity to defend ourselves by ourselves." Sir John Sawyers, the head of UK foreign intelligence agency MI6 claimed that UK's spies foiled Iran's plans to go nuclear as early as 2008 but forecast in July 2012 that Iran would likely achieve nuclear weapons capability by 2014.

Hit by UN economic sanctions for its failure to suspend enrichment and cooperate with the IAEA, Iran was reported to have slowed down accumulation of enriched uranium thus delaying the day when it could breach the "red line". Iran also agreed to permit arranged access by international inspectors to two nuclear facilities but not to the Perchin military site.

After frenzied negotiations the US and five world powers (UK, France, Germany, Russia and China) reached an interim agreement with Iran in November 2013 to curtail Iran's march towards nuclear weaponisation in exchange for economic relief estimated at $7 billion. Under this agreement Iran will stop uranium enrichment beyond 3% effectively giving up the higher levels of enrichment needed to produce a weapon. Iran has also agreed to dilute its stockpile of 20% enriched uranium to lower levels. Greater access to nuclear sites will be given to IAEA inspectors. Further development of the heavy water reactor for plutonium production at Arak will also be put on hold. The world powers assured that no further sanctions would be imposed if Iran sticks to the accord. Though the accord was greeted with relief, the Israeli Prime Minister, Benjamin Netanyahu declared this accord as a "historic mistake" and said that "the agreement does not apply to Israel. If need be Israel will take the matter into its own hands." Saying that weapons with even low level enriched uranium are also feasible, Israel demanded that all enrichment should be halted and "Iran's ability to produce uranium be rolled back". The Iranian Supreme leader Ayatollah Khamenei said, "Israeli leaders cannot be called even humans" and called Netanyahu as "the rabid dog of the region". The ramifications of this accord vis-á-vis the geopolitics of the region will unfold during the on-going exercise for the implementation of the temporary accord and setting the conditions for a permanent agreement that would roll back Iran's nuclear programme. The most complex part involves allowing Iran to enrich uranium only for civilian use "while making sure the know-how is not diverted to military purposes." In the latest round of negotiations, it was Iran's turn to draw a red line saying that it would not scrap any of its nuclear facilities.

While the Shiite Iran was on the threshold of acquiring the bomb, all Arab countries except Syria and Iraq ruled by Sunni Muslims were believed to be contemplating a "Sunni nuclear bomb". The concept of the Islamic bomb mooted by Zulfikar Ali Bhutto was mentioned earlier. To counter Iran's nuclear weapon quest, Saudi Arabia was reported to have turned to Sunni Pakistan which received more aid from Saudi Arabia than any other country outside the Arab world for acquiring a nuclear device. There were even reports that nuclear weapons made in Pakistan on behalf of Saudi Arabia were ready for delivery. Saudi Arabia's announcement in June 2011 of plans to build 16 nuclear reactors over the next 20 years at a cost of more than $300 billion with Pakistan providing the engineering and scientific expertise is also believed to be an additional pointer to the Arab power's move to acquire nuclear weapons capability.

Judging from these developments it appears that more and more states are keen on acquiring nuclear weapons. In such an event the world will get closer to catastrophic end when a nuclear war breaks out.

Tom Lehrer (1928-), the American mathematician, singer, song writer and satirist wrote in the 60s, a poem on nuclear proliferation. It reads

First we got the bomb, that was good,
'Cause we love peace and motherhood.
Then Russia got the bomb, but that is okay
'Cause the balance of power is maintained that way.
Who's next?

France got the bomb, but don't you grieve
'Cause they are on our side (we believe).
China got the bomb, but have no fears,
They can't wipe us out for five years.
Who's next?

Then Indonesia claimed that they
Were gonna get one any day.
South Africa wants two,
One for the black, one for the white.
Who's next?

Egypt's going to get one too
Just to use on one you know who.
So Israel's getting tense

Wants one in self- defense.
"The Lord is our shepherd," says the Psalm
But just in case we better get a bomb.
Who's next?

Luxembourg is next to go
And (who knows?) may be Monaco.
We'll try to stay serene and calm
When Alabama gets the bomb.
Who's next?

Who's next?

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Nuclear War and its Aftermath

States plan their war strategies basing on conventional weapons in a way they can intimidate the adversary through "defeating him or making his victory more costly than the projected gains". This doctrine is known as *deterrence*. The advent of nuclear weapons has introduced a new factor in the strategy. Immediately after World War II, the US launched its nuclear weapons programme, based on deterrence doctrine. With the Soviet Union also acquiring nuclear weapon capability the world entered into a new era of *Mutually Assured Destruction* or MAD. Regardless of who starts a nuclear war, the opponent powers having sufficient nuclear arsenal can launch a devastating retaliatory strike, resulting in deadly consequences to both the powers. Stated briefly, "Don't do it, or it will kill us both." Thus the MAD scenario and *nuclear deterrence* are synonymous. With the spread of nuclear weapons, technology, materials and know-how, the MAD scenario is acquiring greater complexity.

Though nuclear deterrence helped preventing wars between the two nuclear super powers, US and Soviet Union, conventional wars continued to be waged at local level with the nuclear powers being direct parties or acting as proxies. The Soviet Union moved into Hungary in 1956 and Czechoslovakia in 1968. There were major wars in Korea (1950-53), between Israel and Egypt (1956 and 1967), in Vietnam (1959-75), Indian subcontinent (1965 and 1971), Afghanistan (1979-89) (again in 2001 till recent), Kuwait (1990-91), Iraq (2003) and Syria (on going). Ironically nuclear weapons capability could not prevent the collapse of the Soviet Union itself!

It is estimated that at the peak of the cold war, the explosive power of the nuclear arsenals of the two nuclear super powers was of the order of 13,000 megatons (equivalent to a million Hiroshima bombs). This has a potential to destroy life on the planet several times over. A typical thermonuclear warhead has an explosive yield of two megatons. When detonated, about 90 per cent of this energy is released in less than one millionth of a second causing massive destruction over an area 45 kilometres across. This energy is equal to the explosive power of all conventional weapons employed in the entire six year period of World War II (1939-45), the most destructive war ever fought! Bombers, Intercontinental Ballistic Missiles (ICBM) and Submarine Launched Ballistic Missiles (SLBM) capable of hitting all corners of the world are used as the delivery systems for these nuclear warheads This three-branched nuclear capability is called the *Nuclear Triad.* The strategy behind this capability is that a first strike against a country could not destroy all the three legs of the triad. Even if two of the three legs are destroyed, the third (e.g. the SLBM) can inflict a retaliatory strike, thus assuring country's nuclear deterrence capability. Currently the countries with nuclear triad capability are the US, Russia and China. Israel is also suspected to be a nuclear triad power. With the commissioning of the nuclear submarine ARIHANT, India will also be joining the triad group soon. The non-triad nuclear powers include France, UK, Pakistan and North Korea.

The question generally asked is, what could be the consequence of a nuclear war between two nuclear powers? This has been the subject of in-depth analyses of different scenarios by several experts. The study by a team consisting of R. P. Turco, O. B. Toon, T. P. Ackerman, and J. B. Pollock under the leadership of Carl Sagan, the well-known cosmologist, released in 1983 and known as the TTAPS (short for the authors' names) study forecast the outcome of a full-fledged nuclear war between the super powers US and Soviet Union involving thousands of nuclear weapons in their arsenals. Their conclusions which received widest publicity are summarized below.

- The targets will be military and industrial installations as well as big cities in the Northern Hemisphere. Once the bombs begin exploding all communications will fail resulting in chaotic conditions. The psychological fear and the pressure for taking instantaneous decisions affecting the fates of millions of people will result in a *nuclear paroxysm* (a sudden attack or outburst: *a paroxysm of weeping*) among the decision makers.

- About 1.1 billion people, mainly in the Northern Hemisphere (US, USSR, Europe, China and Japan) will be killed outright. An additional 1.2 billion would suffer from injuries and radiation sickness, no medical help.
- The explosions could generate 50 to 100 million tons of smoke and soot particles from the forest and fuel fires. These will get mixed up with the dust consisting of highly radioactive fission products and sucked up by the detonations. A few days later one third to half of these particles will make their way back to the ground as radioactive rain. The fine particles will shoot skyward to a distance of 15 km into the stratosphere. They will then be carried by winds over the entire globe and slowly reach the ground as radioactive fallout for several years.
- As the soot particles reach the sky they block the solar radiation reaching the ground. An estimated thirty million tons of soot that moves up to the Northern Hemisphere would cause a 90 per cent drop in solar radiation reaching the ground. As a result there will be total darkness and a steep fall in temperatures with the minimum reaching -23^0 C. This condition, termed as NUCLEAR WINTER might last several months or even a year.
- One or two weeks after the nuclear strikes, countries in the Southern Hemisphere also will experience a $15\text{-}20^0$ C fall in temperatures.

- The highly energetic nuclear air bursts will burn the nitrogen in the upper atmosphere and convert it to oxides of nitrogen. These reactive oxides in turn combine with the ultra-violet light shielding ozone in the stratosphere leading to its destruction.
- All the above changes in sunlight, climate and the ozone layer will have serious long term adverse effects on all forms of life including vegetation.
- The fires caused by the explosions would produce pyrotoxins through the combustion of plastics, rubber, petroleum and other combustible material. These pyrotoxins include noxious products such as the deadly dioxins, furans, polychlorinated biphenyls (PCBs), cyanides, oxides and acids of sulphur and nitrogen, carbon monoxide and carbon dioxide. Toxic chemicals like ammonia and chlorine released from storage tanks will cause severe chemical pollution.
- Neither the humans nor animals will have anything to eat because no agriculture is possible under the conditions of Nuclear Winter.

  Agriculture production in greater part of Northern Hemisphere will cease for at least one year. Many parts of the Southern Hemisphere will also be affected. Even if some reserves of food are available somewhere, there will be no means of transport to move them to the needy areas because the entire transport system would have collapsed. As a result a majority of survivors face starvation and death.
- Extensive radioactive contamination of the soil and water sources make

large parts of the world uninhabitable for a number of years.

The TTAPS study was widely debated in the media and scientific circles. Understandably the governments and military establishments underplayed the effects. Other studies based on different models predicted somewhat less severe effects but supported the overall conclusions of significant global cooling and its after effects. The debate will continue because any conclusions can be based only on models and perceptions because as warned by Albert Einstein, "The nuclear war is an experiment that can be conducted only once." Assessing the damage caused by the event is out of question! There can however be no two opinions about what Nikita S. Khrushchev, former Secretary General of the Soviet Communist Party said about the global scenario after a full-fledged nuclear war.

"The living will envy the dead"

Several projections are also made on the consequences of an Indo-Pakistan nuclear conflict. The Natural Resources Defence Council, a New York-based non-profit international environmental advocacy group, conducted an analysis (last revised in 2003) of the consequences of an Indo-Pak nuclear war using two scenarios. The first scenario assumed ten Hiroshima-sized bomb explosions over ten cities – Bangalore, Mumbai, Kolkata, Chennai and New Delhi in India and Faisalabad, Islamabad, Karachi, Lahore and Rawalpindi in Pakistan. In the first scenario the bombs will be exploded in the air over each city (like in Hiroshima) with no radioactive fall-out. The total number of persons killed in Indian cities would be 1,609,902 and seriously injured 892,493. With the betrayed inadequacies in its machinery in dealing with disasters like the Uttarakhand floods, India's Disaster Management Authority cannot even comprehend the magnitude of the inferno, let alone its capacity to tackle it. The corresponding figures for the Pakistani cities would be 1,171,879 and 614,400 respectively. In the second scenario in which 24 bombs were detonated at the ground level (12 in each country), with more than one bomb used over some cities, would produce far more horrific results due to deadly radioactive fall-out. The University of Colorado

Boulder, Rutgers University and the University of California, Los Angeles developed in 2007 computer projections for the consequences of an Indo-Pak nuclear conflict involving 100 Hiroshima-sized nuclear weapons (representing a mere 0.05% of the total explosive power of all the currently operational and deployed US and Russian nuclear weapons). According to them

About 20 million people will die from direct effects of the weapons. This number is equal to nearly half the number of people killed in World War II.

Weapons detonated in the large cities in India and Pakistan create massive firestorms which produce millions of tons of smoke. About 1-5 million tons of smoke quickly rise 50 km above the cloud level into the stratosphere. The smoke spreads round the world forming a stratospheric smoke layer that blocks sunlight from reaching the surface of the Earth.

Within fifteen days following the explosions, the temperatures in the Northern Hemisphere would become colder than those experienced during the preindustrial Little Ice Age.

The nuclear war-induced effects on temperatures would be twice as large as those which followed the volcanic eruption in 1816 which caused "The year without Summer".

The cold weather would also cause a 10% reduction in average rainfall and a large reduction in the Asian summer monsoon.

25-40% of the protective ozone layer would be destroyed at the Mid-Latitudes and 50-70% would be destroyed at the Northern

High Latitudes. As a result there will be a massive increase in harmful UV-light with significantly adverse effects on the human, animal and plant life,

There will be changes in global climate also. It will be too cold to grow wheat in most of Canada.

World grain stocks would be completely depleted.

Grain-exporting nations would likely stop exports to needy nations to meet their domestic needs. Food shortages would affect the lives hundreds of millions of already hungry people, who depend upon imported food. They will starve to death during the years following the nuclear conflict

The International Physicians for the Prevention of Nuclear War and Physicians for Social Responsibility warned in April 2012 that an Indo-Pakistan nuclear conflict, even if it is restricted to the region, would cause major worldwide climate disruption driving down food production in the US, China and other countries.

Even if one of the combating nations claims victory it can only be a pyrrhic victory!

How long will a nuclear war last? Conventional wars are fought over several years. For example World War II lasted for six years (1939- 1945). A nuclear war is waged with tactical nuclear weapons and strategic nuclear weapons. A war fought with tactical weapons targets specific targets. Since this involves objectives, specific targets based on critical assessment the war could last some time, say weeks or even months. A war involving strategic nuclear weapons is however aimed at obliterating the enemy with no means to survive and counterattack any more. Such a war will be over in a matter of days if not hours! In the case of a nuclear war between two abutting nations such as India and Pakistan, nuclear weapons delivered by missiles could hit their targets in 3 to 7 minutes depending on location and cause horrendous loss of life and property before the public even becomes aware of what is happening!

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On the Brink of a Nuclear War

Though the Cold War is marked by nuclear deterrence strategy through the buildup of nuclear arsenals capable of destroying life on the planet, not a single nuclear weapon was used in any of the wars that followed World War II. The Cold War terminology came from the fact that "it never became a shooting war *per se* but more of a cat and mouse game." On several occasions nuclear powers only considered invoking, for political advantage in times of international crises, their nuclear option to deter aggression. The US considered the possibility of using nuclear weapons in the Korean War but dropped the idea. When France was facing insurgency in Vietnam in 1954, the possibility of saving the French forces under siege in Dien Bien Phu through the use of nuclear weapons was considered. When the islands of Jimmen and Mazu (Quemoy and Matsu) which were under the control of Taiwan were bombarded by the Chinese Communist Government in 1954, President Eisenhower threatened the use of nuclear weapons. During the Suez crisis in 1956, Khrushchev and Bulganin threatened UK and France with nuclear attacks if they did not withdraw their forces from Egypt. A similar note was also sent to Israel which was providing support to UK and France. The Berlin crisis of 1961 turned out to be so serious that at one stage leaders feared that a misstep could trigger a nuclear war. The crisis however ended with the erection of the Berlin Wall. Throughout the Cold War the nuclear armed submarines operated by the nuclear powers were in the forefront of both defence and offence operations, cruising off the opponents' bases and protecting their own bases from possible attacks.

There were also occasions when crises mounted to stages when nuclear options appeared inevitable. The Cuban missile crisis, which almost triggered a nuclear war between the US and the Soviet Union, was an event that put the world on tenterhooks for thirteen days starting October 16, 1962. An unsuccessful adventure by US backed Cuban exiles, called the Bay of Pigs Invasion, to overthrow the Cuban dictator Fidel Castro was the precursor to this crisis. Fidel Castro began looking for means to defend Cuba from another attack. While the US could attack the Soviet Union with its long and medium range missiles based in Europe, the Soviet Union could not counter the attack as it was lagging behind in its long range ICBM programme. When Castro approached for support Khrushchev readily responded by agreeing to install Intermediate Range Missile bases in Cuba, since this provided the Soviet Union the opportunity to defend itself against a possible US attack. When the installation of the Soviet missile bases was revealed to the US by reconnaissance, President Kennedy immediately ordered quarantining Cuba and announced US readiness for attack using even nuclear weapons. President Kennedy in a letter dated October 22 to Khrushchev said, "... I have not assumed that you or any other sane man could, in this nuclear age deliberately plunge the world into war which is crystal clear that no country would win and which could only result in catastrophic consequences to the whole world, including the aggressor." Frantic diplomatic activity involving US, Soviet Union, UK and France and former US Presidents followed. The crisis was finally defused by Khrushchev backing out from the adventure. In his letter dated 26 to President Kennedy, Khrushchev said, "If, however, you have not lost your self-control and sensibly conceive of what this might lead to, then Mr. President, we and you ought not now to pull on the ends of the rope in which you have tied the knot of war, because the more the two of us pull, the tighter the knot will be tied. And a moment may come when that knot will be tied so tight that even he who tied it will not have the strength to untie it, and then it will be necessary to cut that knot and what that would mean is not for me to explain to you, because you yourself understand perfectly of what terrible forces our countries dispose. Consequently if there is no intention to tighten the knot and thereby to doom the world to the catastrophe of a thermonuclear war, then let us not only relax the forces, pulling the ends of the rope, let us take the means to untie the knot. We are ready for it." When in a private letter to Khrushchev, Castro suggested that the Soviet Union be prepared to launch a preemptive nuclear strike against the US, Khrushchev reacted strongly and wrote to him explaining the catastrophic consequences of a thermonuclear war. He further stated that the US also understood this. The world heaved a sigh of relief when a deal was reached by which the Soviet would dismantle the weapons sites in exchange for a pledge from the US not to invade Cuba. In a separate deal, which remained secret for more than 25 years, the US also agreed to remove its nuclear missiles from Turkey. Ironically the Cold war and arms race continued!

In view of the great risks involved in the use of even a single nuclear weapon the nuclear superpowers evolved and put in place stringent measures to ensure that nuclear explosives are used only under properly authorized circumstances and never detonated either unintentionally or by accident. This protocol is known as *command, control, communication, computers and intelligence* (C^4I). The nuclear weapons are guarded with electronic locks with a secret code which has to be inserted before the operators can act. This code which is changed periodically is kept under close guard with the decision-making authority.

The command and control authority of US is vested in the Nuclear Command Authority (NCA) comprising the President, the Secretary of Defence and "their duly deputed alternates and successors", with the chain of succession clearly spelt out. The US President is the authority to order attacks by the US forces. He is always accompanied by a military attaché, carrying the briefcase, called the NUCLEAR FOOTBALL, which contains among others the launch codes, the procedures and authentication orders for launching nuclear weapons. In Russia the ultimate control of nuclear weapons lies with the President who is also the Supreme Commander. He is advised by a Defence Committee. The Russian nuclear briefcase is called CHEGET, which allows the Russian President to monitor the crisis and make decisions. In the UK the Prime Minister exercises the authority over nuclear forces. He can order the use of nuclear weapons with assistance of one person, possibly the Chief of Defence Staff. This two person rule operates throughout the nuclear command chain from the Prime Minister to the servicemen in the field. The complete codes for authorizing a nuclear strike are held by both individuals and only when the sections are brought together can a fully authenticated launch order be transmitted to the nuclear forces. In France the President exercises supreme command over all nuclear forces. His autonomy of decision is almost completely unlimited. As China is an authoritarian state not much is known about the linkages of its nuclear command and control structure. Essentially the Chairman of the Central Military Commission of the Communist Party would decide on the use of nuclear weapons.

India has established a Nuclear Command Authority that includes a Political Council and an Executive Council. The Prime Minister chairs the Political Council which is the sole body to order a nuclear strike. It includes home, defence, finance and external affairs ministers. It includes the three service chiefs, top officials from DRDO, Department of Atomic Energy and others to provide inputs and execute directions given to it by the Political Council. Alternative chains of command are also established if the political leadership is "decapitated" in a first strike. The nuclear arsenal is placed under the charge of the

Commander-in-Chief of the Strategic Forces Control Command.

In theory the Prime Minister of Pakistan is the Chairman of the country's Nuclear Command Authority, which handles the command and control of its strategic nuclear forces. But it is the military that enjoys absolute authority over the control and use of nuclear weapons. Among all the nuclear weapon states Pakistan is the only country where the nuclear assets are effectively under the command and control of the military and not the civil authority.

During the Clinton Administration the codes used by the US President were mislaid for months but were promptly replaced. In Russia in 1980, a group of inspecting officers from the general staff was visiting Strategic Missile Force Headquarters. They asked Gen. Georgy Novikov what he would do if he received the missile launch order but the safe containing the launch codes failed to open. Novikov replied that he would "knock off the safe with a sledgehammer" which he kept nearby!

Unauthorized strikes ordered by an individual or agency other than the appropriate authority, such as a rogue general or a mad submarine commander, could spark off a nuclear war. Unforeseen breakdown of systems could result in accidental strikes. Decisions based on incomplete information and even errors in intelligence reports could also trigger a nuclear war. During the Cuban crisis ninety eight Soviet tactical nuclear weapons were located in Cuba and the Soviet ground commanders were authorized to use these weapons should the US choose to invade Cuba. Some Soviet submarines escorting ships to Cuba were also armed with nuclear tipped torpedoes. The US intelligence was however not aware of this. On October 27, 1962, which was considered the most dangerous day of the Cuban Crisis, a series of depth charge attacks were made by the American destroyer USS Beale on a B-29 Soviet submarine carrying a nuclear-tipped torpedo. In the absence of communications from Moscow, the commander of the Soviet submarine believed that war between the US and Soviet Union had begun. He prepared to fire the nuclear torpedo at the giant aircraft carrier USS Randolf, which was leading the US taskforce. However authorization to fire the torpedo required the concurrence of three officers on board. Two were in favour of launching the weapon while the third officer Vasili Alexandrovich Arkhipov was not. As a result the launch was stalled. Kennedy and Khrushchev were not in the know of these developments! If the nuclear torpedo was fired the carrier would have been destroyed and the US would have retaliated. The nuclear war would have spread from sea to land. The first targets would have been Moscow, London, the air bases of East Anglia and troupe concentrations in Germany. "The next wave of bombs would have wiped out economic targets, a euphemism for civilian targets." According to one CIA officer, "October 27 is a day I will never forget. The planet could have been destroyed." The world owes a debt of gratitude to Arkhipov, the saviour! His decision was certainly worthy of the Nobel Prize for Peace!

Another incident which nearly led to a nuclear war due to judgment error occurred on January 25, 1995, four years after the Berlin Wall was brought down and the mistrust between Russia and the US was persisting. On that day Norway launched a research rocket from a Norwegian offshore island to study the Northern Lights. The rocket launch with separation of multiple stages and bearing the radar signature looking just like a US submarine launched Trident missile, led the officer at Russia's Olengursk believe that it could be a nuclear attack. Boris Yeltsin was alerted and immediately given the Cheget to connect to senior officials. The nuclear submarine commanders were ordered to be on full battle alert, pending instructions. Fortunately Yeltsin, who was not sure that the US would attack, was wavering in ordering a retaliatory attack. Within five minutes the Russian radar signaled that the missile was harmlessly headed out to sea. The final decision not to launch a nuclear missile attack was given short of the ten-minute deadline. Similar erratic intelligence episodes have also been reported earlier during 1979, 1980 and 1983. Some US militarists even fear that the impact of an asteroid could be mistaken for a thermonuclear explosion, triggering a nuclear war.

Unforeseen events also could trigger nuclear weapon explosions leading to destruction of life and property over a wide area. One such episode was reported by a Deputy Commander-in-Chief of the Russian Strategic Rocket Forces. According to him, "Following a heavy rainfall, water leaked into a silo and flooded a missile. Had there not been a short circuit in the missile system, Ukraine would not have escaped a second Chernobyl." In another incident the US escaped a disaster worse than the devastation brought in Hiroshima and Nagasaki. On January 24, 1961 a US B-52 air force bomber broke in half in mid-air and two nuclear bombs with an explosive yield of 3.8 megatons (the yield of Hiroshima and Nagasaki bombs was 0.03 megatons) hit the ground in North Carolina. In the words of Robert McNamara, the then US Secretary of Defence, "By the slightest margin of chance, literally the failure of two wires to cross, a nuclear explosion was averted."

Boris Gorbachev once observed, "It is entirely possible for a man worn out by problems of daily life to make a mistake when carrying out work on nuclear rockets. This would not only trigger a chain reaction of nuclear charges but would scatter nuclear materials over dozens of kilometers."

In the current global scenario the real danger of a nuclear war lies in the possibility of a rogue state acquiring nuclear weapons capability. Even without access to a delivery system (missile or an aircraft), the state can use the weapons in local conflicts directly or through terrorists. The danger could be greater if a wide variety of portable nuclear weapons are developed through advanced technology.

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Nuclear Weapons-free World - An Illusion?

While the human society has been making efforts over the past century to reduce the chances of warfare, technology has been providing it with means to wage increasing deadly wars. A horrified world raised its voice against the atomic bombing of Hiroshima and Nagasaki in 1945. A second wave of protests began in the 1960s as multiple US and Soviet hydrogen bomb tests caused the vast devastation they produced. Prominent scientists and intellectuals such as Albert Einstein, Linus Pauling, Albert Schweitzer, Bertrand Russell and several public organizations opposed nuclear testing and nuclear war. The initial response of the nuclear powers to the public uproar was the Partial Test Ban Treaty (1963) prohibiting testing of nuclear weapons except underground. This was followed by the Nuclear Non Proliferation Treaty (1968) aimed at limiting the spread of nuclear weapons, creating a nuclear cartel among the nuclear weapons states. Sweden began its nuclear weapons programme in the 50s but gave it up a decade later partly due to security assurances from the US. Taiwan abandoned its programme in the 70s. Australia explored and finally gave up its nuclear option in the 70s. Brazil and Argentina, both well advanced in their capacity to acquire nuclear weapons froze and dismantled their programmes in the 80s. South Africa decided to dismantle its stockpile of six nuclear weapons in 1993. Ukraine decided to give up the 1,900 nuclear warheads it acquired from the disintegrated Soviet Union in 1991. Some nations (UK and France) unilaterally reduced their nuclear weapon stockpiles. The US and the Soviet Union, the two top nuclear weapons states holding bulk of the nuclear weapons have been entering into a number of bilateral treaties aimed at nuclear weapons control and reduction. The major treaties will now be outlined.

After the Cuban Missile Crisis of 1962 The US and

Soviet Union agreed to install a direct hotline between Washington and Moscow enabling the leaders of both countries to quickly interact with each other and reduce the chances of an all-out nuclear war. This was followed by détente, the period from 1967 to 1979 marked by the easing of geopolitical tension between the two nuclear super powers US and the Soviet Union by signing SALT I Treaty (Special Arms Limitation Treaty I) freezing the number of ICBMs and SLBMs(Submarine Launched Ballistic Missiles) they would deploy. The SALT II Treaty of 1979, which replaced SALT I, and signed by US President Carter and Soviet Leader Brezhnev in 1979, limited both US and Soviet Union to an equal number of ICBM launchers, SLBM launcher and heavy bombers, and also placed limits on the Multiple Independent Reentry Vehicles (MIRV). But it did little to stop or even slow down the arms race. With invasion of Afghanistan by the Soviet Union in 1979, the Treaty never came into effect.

The Intermediate Range Nuclear Forces (INF) Treaty of 1987 signed by US President Reagan and Soviet Leader Gorbachev represents the first nuclear arms control agreement to actively reduce nuclear arms through the elimination of all nuclear armed ground launched ballistic and cruise missiles with ranges between 500 and 5,500 km. The Treaty also provides for an intrusive verification regime. It marked the beginning of the end of the Cold War that ultimately led to the break-up of the Soviet Union.

The Strategic Arms Reduction Treaty I (START I) was signed by the US President George Bush and the Soviet leader Gorbachev in 1991. Under this Treaty the US and the Soviet Union agreed to reduce their nuclear warhead stockpiles by about a third. But it leaves the US and the Soviet Union with 9,000 and 7,000 warheads respectively. The Soviet Union collapsed in December 1991. The START I Treaty came into force in 1994.

The Strategic Arms Reduction Treaty II (START II) was signed by US President George Bush and the Russian President Boris Yeltsin in 1993. This agreement commits the US and Russia to deploy not more than 3,000 to 3,500 warheads each by 2007 and also prohibits against deploying MIRVs. The Treaty was however not put into force after the US and Russia concluded negotiations on Strategic Offensive Reductions Treaty (SORT) 2002. The Treaty signed by US President George Bush and Russian President Vladimir Putin commits the two countries were to reduce their deployed warheads to 1,700 to 2,000 apiece by 2012. After this date both sides are free to decrease or increase the size of their deployed forces. Significantly there is no provision for verification. This Treaty was slated to expire in December 2012.

The New Strategic Arms Reduction Treaty (START III) replacing SORT was signed by US President Obama and the Russian President Medvedev in 2010. Under this Treaty the number of strategic missile launchers will be reduced by half. A verification regime will be established for the purpose. It does not however limit the number of operationally inactive stockpiled nuclear warheads in the US and Russian inventories. After ratification by US and Russia, the Treaty has entered into force in February 2011 and is expected to remain in force till 2021.

Three major multilateral (international) treaties have also been entered into. The Nuclear Non Proliferation Treaty (1968) which has entered into force in 1970 was ratified by as many as 190 countries. Only four countries-Pakistan, India, Israel and North Korea are not parties to the Treaty. The Comprehensive Test Ban Treaty (CTBT), which bans all nuclear explosions, for military or civilian purposes, was adopted by the UN General Assembly in September 1996. Clause XIV requires ratification by 44 named states before it comes into force. Of these India, Pakistan, and North

Korea have not signed. US, Egypt, Indonesia, Israel and Iran have signed but not ratified the Treaty. The Fissile Material Cutoff Treaty (FMCT) is an international agreement that would prohibit the production of the main ingredients of nuclear weapons- highly enriched uranium (HEU) and plutonium. Those nations that joined the NPT as non-nuclear weapon states (NNWS) are prohibited from producing or procuring these materials for weapons production. The Treaty also places restrictions on the nuclear weapons states (US, UK, France, Russia and China) on supplying these materials to the countries that are not parties to the NPT. International consensus is yet to be arrived at on the final form of the Treaty.

Notwithstanding these international treaties as well antipathy from the civil society, the pace of nuclear disarmament is protracted with the five Nuclear Weapons States reluctant to completely part with their nuclear weapons. Because of the secretive nature with which most governments treat the information about their nuclear arsenals, it is only possible to estimate the nuclear weapon inventories these countries hold. The Arms Control Association, Washington D.C. arrived at the following figures in May 2012.

US: App. 5,000 warheads (1,737 deployed strategic, app. 500 operational tactical (some deployed in Europe).

Russia: App. 5,500 warheads (1,492 operational strategic, app. 2,000 operational tactical and app. 2,000 in reserve storage).

UK: 225 warheads (Fewer than 160 deployed strategic).

France: Fewer than 300 operational warheads.

China: About 240 warheads.

The nuclear warheads believed to be held by non-NPT states are

India: Up to 100 nuclear warheads.

Pakistan: Between 90 and 110 nuclear warheads.

Israel: Between 75 and 200 nuclear warheads.

North Korea: Enough plutonium for 10 nuclear warheads.

Only Russia and the US have been reducing their nuclear warheads while France, UK and Israel kept their warhead numbers unchanged. The nuclear arms race among the Asian powers continues with China, India and Pakistan each having added ten warheads over the last one year. The Pulitzer Centre, Washington, DC reported in September 2012 that Pakistan is believed to be churning out more plutonium than any other country. It has already passed India in total number of warheads and is on course to overtake Britain as the world number 5 nuclear power. It could also end up in third place behind Russia and the US in a decade.

The question that comes to one's mind is "Is it possible to achieve total nuclear disarmament (nuclear zero) and save the world?" The need for total nuclear disarmament was stressed by the International Court of Justice (ICJ) in a landmark judgment in 1996. The Court ruled that "there exists an obligation to pursue in good faith and bring to a conclusion negotiations leading to nuclear disarmament in all its aspects under strict and effective international control." At the NPT Review conference held in 2000, one of the steps agreed to was "an unequivocal undertaking by the nuclear weapons states to accomplish the total elimination of their nuclear arsenals leading to nuclear disarmament to which all state parties are committed under Article XIV." But the nuclear weapon states (NWS) say that they are not committed to total nuclear disarmament. They also argue that there is no time frame other than to end the arms race "at an early date."

They also argue that the ICJ ruling was not binding.

The NWS continue to hold huge inventories of nuclear weapons, despite the fact that the threats to their survival have considerably reduced, largely because of the end of the Cold War and an increasing realization that their common interests (e.g. economy) greatly outnumber their differences. There is always a chance that these weapons will be used by accident or deliberately. George Wald says, "Nuclear weapons offer us nothing but a balance of terror; and a balance of terror is still a terror." There are even reports that the NWS are developing more sophisticated weapons and delivery systems. The US President Obama declared that as long as nuclear weapons existed the US would keep its own arsenal. Russia and China have both announced upgrades to their nuclear arsenals and so has the UK with plans to build new nuclear submarines with Trident missiles. More ominous is the fact that there now exist capabilities and know-how to make nuclear weapons anywhere *with little chance of detection*. This development threatens international stability. John Browne, a former head of Los Alamos National Laboratory says, "Things were a lot easier when it was just the US and the Russians."

Even small nations are on the look-out for nuclear weapons as deterrents in theatres of enduring rivalries such as Asia and Middle East to challenge stronger adversaries. Holding nuclear weapons whose number can be counted on fingers the tiny state of North Korea has the temerity to thumb its nose against the nuclear super power US. Ukraine has surrendered its nuclear arsenal on receiving a guarantee from Russia, US and UK that its borders were safe. But when Russia occupied Crimea the US did not intervene. Ukraine must be now regretting its earlier decision. With the rapid development of an "arc of instability from Afghanistan, through Iraq and Syria, to Israel and beyond to Egypt and Libya" some Gulf States could hasten to secure nuclear capability with assistance from Pakistan. The danger of a nuclear war between India and Pakistan is much greater than it was between the US and Soviet Union during the period of Cold War. This is due to the hold of fundamentalist militants within the Pakistan army and the absence of effective democratic control. With China pursuing its geopolitical and geoeconomical ambitions more aggressively in the Pacific, the smaller nations in the region could also scout for nuclear deterrence. As a result there could be an international market for nuclear weapons. These growing strains between nations in Asia and Middle-East could ultimately transform the region into *a potential nuclear tinderbox*.

When small nations without adequate nuclear security acquire nuclear weapons, there is a risk of the weapons finding their way into the hands of terrorist agencies. Pakistan's nuclear weapons face the risk of theft by Islamic extremists, who could use these weapons. Gareth Evans and Yoriko Kawaguchi, Foreign Ministers of Australia and Japan respectively who acted as Chairman and Co-chairman of the International Commission on Nuclear Non-Proliferation and Disarmament in their Report (2009) said that a nuclear bomb, comparable to the one dropped on Hiroshima, detonated by terrorists inside the back of a large van in London's Trafalgar Square in middle of a work day, could cause an estimated 115,000 fatalities and another 149,000 injuries from a combination of blast, fires and radiation exposure. When such a bomb is detonated in the population-dense Central Mumbai, the figures would be more than 481,000 fatalities and 709,000 injuries! Yasin Bhatkal, chief of the Indian Mujahudeen terrorist organization is reported to have confessed to his interrogators (TOI, Dec. 30, 2013) that he wanted to explode a small nuclear bomb in Seurat and that he asked his Pakistan-based boss Riyaz Bhatkal, over phone whether the latter could arrange one for the purpose. Riyaz was reported to have told Yasin that "anything can be arranged in Pakistan." Fortuitously Yasin was arrested before things moved further.

In such an environment the chances of seeing a nuclear-free world in the foreseeable future appear to be very slim. But this should not deter the human society from making sincere efforts to achieve the nuclear weapon-zero target for its very survival. It is no doubt a slow and complex process. Sergei Ivanov, a former Russian Prime Minister (2005-2008) said, "Do I believe in global zero? Not in my lifetime. But if we don't start, never in the lifetime of my grandchildren."

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The Genie with Janus Face

In Roman mythology Janus is the two-faced God of beginning and ending with one face to the front and one to the back. In certain situations the Janus-headed figure is also used to describe two contrasting aspects - progressive and retrogressive. Metaphorically the nuclear genie can be described as double-faced Janus with progressive and retrogressive powers. The nuclear genie has so far been pictured as a satanic figure capable of even destroying life on earth. The second face however represents a progressive feature, which can be described as an energy reservoir that can meet the growing world energy needs. That nuclear energy could replace the steam engine in electricity generation was forecast by H.G. Wells as early as 1914. The feasibility of extracting the energy from nuclear fission chain reaction in a controlled manner for electricity generation through a device called nuclear reactor has been demonstrated by Enrico Fermi on December 2, 1942. This demonstration also opened up the possibility of producing nuclear weapons. With the world war raging at the time, building nuclear weapons naturally received priority.

With the cessation of hostilities, programmes were initiated for the development of nuclear technology for power generation. The US, with its technological head start in this field through the wartime Manhattan Project, took the lead in the generation of electrical power from nuclear fission energy. The first US electricity producing prototype reactor went into operation in 1951 at Idaho generating an electrical power of 250 kW (250 KWe), just enough for the reactor building. This project led to the launching of the first nuclear submarine *Nautilus* in 1955. The Soviet Union commissioned its 5 MWe nuclear power plant at Obninsk in 1954. The first fully commercial reactor with a power output of 250 MWe became fully operational in 1960 in US at Yankee River. France, UK, USSR, Canada and Sweden also pioneered the development of nuclear technology for power generation. In due course many countries including India received assistance from these countries in the installation of nuclear power plants to meet their power requirements. The oil crisis of 1973 had a major effect on several countries which relied on oil for their energy needs. To meet the crisis, they pushed for nuclear energy for power production.

Nuclear fission energy has several significant features that make nuclear power production very attractive. Unlike fossil fuels (coal, oil and gas) it does not produce carbon dioxide (greenhouse gas). It produces extraordinarily high energy density per unit weight of the fuel. Just 1kg of uranium-235, when it completely undergoes fission, would give the same thermal energy (heat) as 2,500,000 kg of coal. Nuclear power plants are economical at places where transport of conventional fossil fuels would be expensive.

In 1960 worldwide nuclear power production was less than 1 GWe in 1960. This rose to 100 GWe in the 1970s and then to 300 GWe in the late 1980s. Since then the production rate rose much more slowly, to reach 366 GWe in 2010 from 439 nuclear reactors in 31 countries, providing about 16% of the world's electricity. This is projected increase to 20% (1000 GWe) by 2050 (MIT Report 2009). The US produces the most, with nuclear power providing 20.2% of its electricity in 2009. France produces the highest percentage (75.2%) of its power needs from nuclear reactors. The European Union as a whole gets 30% of its electricity from nuclear energy.

India's nuclear research programme began with the creation of the Atomic Energy Establishment Trombay (later named Bhabha Atomic Research Centre) at Mumbai consolidating all research and development activity in nuclear reactors and technology under the Atomic Energy

Commission. The first two commercial nuclear power reactors in India were commissioned in 1969 at Tarapur. Then followed more nuclear power reactors at Kota (Rajasthan), Kalpakkam (Tamilnadu), Kaiga (Karnataka), Narora (UP), Kakrapar (Gujarat), and recently at Kudankulam (Tamilnadu). These reactors numbering 21 have a total power output of 5780 MWe contributing about 3.5 per cent of the country's total power generation.

A major hurdle faced by India in its nuclear power programme has been the shortage of domestic uranium. This shortage has been further exacerbated by the international sanctions imposed in the wake of India conducting nuclear tests in 1974 and 1998. The recent Indo-US nuclear agreement and other agreements that followed have enabled India to import uranium fuel and boost its nuclear power production programme by improving the power generation in the existing reactors, accelerating the commissioning of the commercial rectors under construction (numbering six with a total power output of 4300 MWe), and also planning for more power reactors with indigenous expertise as well as foreign collaboration. India has now set before itself an ambitious nuclear power production target of 20,000 MWe by 2020 and 63,000 MWe by 2030.

Energy is the motive force for the growth of modern civilization. A million years ago the primitive man relied only on the energy from the food he consumed. Currently the technological man consumes more than hundred times this quantity. This energy is used in the form of food, home and commercial purposes and in power production, industry, agriculture and transport. This enormous growth in energy consumption is made possible by increased use of coal as a source of heat and power use of internal combustion engines which led to the massive use of petroleum and derivatives electricity generated by hydro sources and thermo electric plants using coal, oil and gas and lately nuclear energy.

Global energy demand has been increasing rapidly and more dramatically in fast growing economies in Asia (India and China). With energy consumption in 2012 of 774 Million tonne Oil equivalent (MtOe) (for transport, agriculture, industry, domestic use, and power production) compared to 2,713 MtOe by China and 2,152 MtOe by the US, India stands third among high energy consumers (Global Statistical Year Book, 2013). In the matter of electrical power, India with an annual per capita power consumption of about 750 units stands low at 154 among 214 countries ranked. In contrast the US with a per capita annual consumption of 13,246 units ranks 9 while the UK with a per capita power consumption of 5,472 units ranks 47. One third of India's population is not connected to electricity grid. The shortage of electrical power is affecting India's competitiveness in commerce with China, Thailand and South Korea. India's power generation must grow fourfold to meet its rising requirements. Currently coal provides 59 per cent of electricity generation. Gas provides 9 per cent and hydro 17 per cent, renewable 12 per cent and nuclear 3.5 per cent. How does India currently meet these energy requirements?

The total estimated domestic coal reserves as of March 2010 were about 277 billion tonnes. But mining and extraction of these deposits are affected by geological, technical and other surface constraints such as townships, river beds, high environmental fragility due to location of deposits deep underneath pristine forests and human settlements. These factors result in high economic and social costs in exploiting some resources. Further, the ash content of Indian coal is also a problem in the efficient operation of thermal power plants. These factors necessitated the import of 159 million tonnes of coal (18 per cent increase) in 2013 against the domestic production of 533 million tonnes.

The demand for oil (mostly for transport) has been spectacular. The gap between India's oil demand and supply is widening as the demand reached nearly 3.7 million barrels per day in 2013 compared to one million barrels per day of domestic production. By 2040, the demand is projected to rise to 8.2 million barrels per day with the domestic production remaining almost flat around one million barrels per day.

Import of liquid natural gas at 39.32 million standard cubic metres a day contributed 25.5 per cent of the total fuel consumed in 2011-12. As the output from domestic sources stagnates, the import of natural gas will surpass domestic production in two years.

Shale gas is available but yet to be exploited. It requires huge quantities of water, already scarce, and results in extensive land disturbance.

As a result of international price escalation and growing imports of these fossil fuels, India's total foreign exchange outgo on the import of energy has been growing at an alarming rate, close up to 20 percent per year with an increase of almost 55 times over the past two decades. This increasing dependence on fossil fuels also places India at the mercy of international price fluctuations. More worrying is the realization that the use of these fossil fuels is already having adverse effects on the environment.

India has significant hydro power potential. But it suffers from drawbacks like location and social (population displacement) issues.

Solar and wind energy sources can meet only part of the consumerr needs.

All the above factors make nuclear energy an important option to meet the country's fast growing energy needs of the twenty first century. A sound long term energy strategy should necessarily be based on an energy mix of different sources of energy with nuclear energy as an essential component. Nuclear power no doubt is not perfect. But no generation source is. In present state of things it is the best viable high density energy source that can displace coal-based power plants.

Nuclear power has however been the subject of serious debate ever since the use of nuclear weapons over Hiroshima and Nagasaki. This debate has intensified in the wake of major reactor accidents at Three Mile Island (1976) and Chernobyl (1986). In fact these accidents resulted in a setback to the growth of nuclear power for some time. Just when the expansion activity was reviving in the 21st century, a major tsunami disabled three power reactors in Fukushima Daiichi in March 2011, sparking off opposition to nuclear power generation. Such accidents anywhere in the world would stoke antinuclear backlash amongst the public everywhere. Other factors that cause apprehension among the public are radioactive waste, proliferation of fissionable materials like plutonium and nuclear terrorism. The nuclear power industry has been actively engaged in research and development aimed at achieving safety and efficiency of nuclear power reactors through improved technology. It is also actively addressing environmental concerns such as handling the spent nuclear fuel and the safe disposal of the dangerous radioactive wastes. Whether we like it or not there is presently no alternative to nuclear power to meet the country's fast rising energy needs.

We end this narrative with a word of caution. The Nuclear Genie is seen both as a destroyer of life and a potential energy provider. The fate of the world hinges on how diligently the society bridles this Genie and guides it on the path of energy security.

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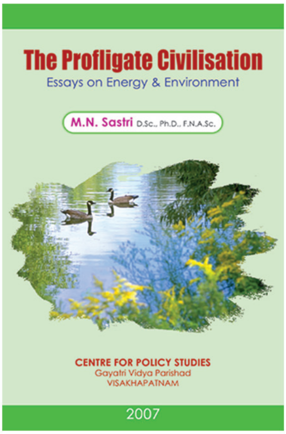

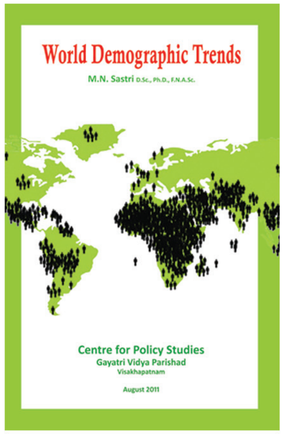

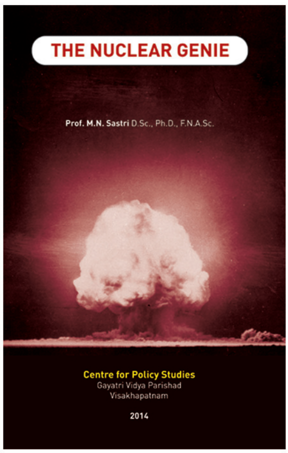

To

Prof. M.N. Sastri

with Greetings on his
90th birthday and grateful thanks

Centre for Policy Studies
August 5, 2014

Prof. M.N. Sastri D.Sc., Ph.D., F.N.A.Sc.

Dr. M.N. Sastri, Retired Professor and Head of the Department of Chemistry, Andhra University, is a distinguished scientist and prolific writer on energy and environment.

Born on August 5, 1925, he studied at the Andhra University where he obtained the M.Sc degree in 1947 and D.Sc in 1951. He went to the United Kingdom on a Government of India scholarship for higher studies and took the Ph.D.degree from Durham University in 1958.

Joining the Andhra University's Chemistry Department in 1948 as a demonstrator, Dr Sastri became Reader in 1959 and Professor in 1966. He carried out extensive studies in the fields of Volumetric Methods Chromotography, Precipitations from Homogenous Solutions, Chemical Kinetics and Tracer Methods. He organized the first full- fledged M.Sc course in Nuclear Chemistry in the University and was the Founder-Vice President of Indian Association for Nuclear Chemists and Allied Scientists. Prof. Sastri was mainly responsible for establishing the Centre for Nuclear Techniques in Andhra University with financial support from the Atomic Energy Commission. He was Visiting Professor at La Trobe University Australia in 1976 and Adjunct Professor, San Jose State University, USA in 1986 and Fellow, National Academy of Sciences, Allahabad.

Prof. Sastri received the P.C. Ray Gold Medal of the Calcutta University for contributions in analytical chemistry and the Dr. M.V. Ramanaiah Memorial Award from Indian Association for Nuclear Chemists and Allied Scientists for Life Time Achievements and contributions to Radio Chemistry. This is Prof. Sastri's third book published by Centre for Policy Studies. ***The Profiligate Civilisation in 2007 and World Demographic Trends in 2011*** were his previous works. ***History of Planet Earth, Vistas in Analytical Chemistry, Water, Introduction to Environment and Weapons of Mass Destruction*** are among the other books authored by him. He has served on several expert bodies at the state and national levels. Prof. M.N. Sastri and his wife Mrs. Sarala Sastri live in Mumbai.

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