NUCLEAR SAFETY-SECURITY-SAFEGUARDS: THE INTRICATE INTERFACE

SITAKANTA MISHRA

Since its inception, nuclear technology has evoked a sense of zeal as well as awe because of its immense constructive and destructive potential. By now, the world has come a long way, experiencing both: around 540 nuclear reactors operating in 31 countries producing 372,000 MWe (13.5 percent of the world's electricity)[1], radioactive materials used in many sectors enriching human life; on the other hand, two nuclear bombs have been used in war and around 19,000 more are stockpiled; during the same time, three major nuclear accidents occurred,[2] resulting in some human suffering, and misuse of nuclear material by non-state actors is widely apprehended. Therefore, the balance sheet may be argued to be mixed, implying that we succeeded as much we failed with nuclear technology. After the Fukushima nuclear disaster, what would be the fate of nuclear technology or which direction the nuclear energy discourse will move in has been a matter of speculation. This study, premised on the assumption that nuclear technology or nuclear energy *cannot be ignored* as it has an edge over other forms of energy, argues for a better management paradigm by *looking beyond the design basis threats* to address inherent loopholes. Deconstructing the real and assumed threats (accident, misuse, and terror), this study prescribes a

Dr **Sitakanta Mishra** is a Research Fellow at Centre for Air Power Studies, New Delhi.

1. World Nuclear Association, "Nuclear Power in the World Today", http://www.world-nuclear.org/info/inf01.html
2. Chernobyl (USSR), 1986; Three Mile Island (USA) 1979; and Fukushima (Japan) 2011.

coherent and integrated strategy devoid of political and social panic.

EDGE OVER OTHER FORMS

Despite the past half century's global experience, it is not yet fully established that "nuclear power has an edge over other forms of energy, in terms both of limiting day-to-day adverse health and environmental effects, including greenhouse gas emissions, and in terms of the frequency and toll of major accidents".[3] In comparison to coal, gas, hydro, and wind energy sources, the morbidity and greenhouse gas emission per terawatt-hour in the case of the nuclear energy source is much lower. According to a study by Edward D. Blandford and Michael M. May of the American Academy of Arts and Sciences, nuclear energy, that constitutes 14 percent of global energy consumption, has the lowest morbidity (0.04) compared to the coal-related energy production process (161) that constitutes 42 percent of global energy consumption. In terms of greenhouse gas emissions, while coal produces 800-1,400 tons per gigawatt-hour, the nuclear industry produces less than 50 tons.[4]

Table 1: Sources of Electricity, their Morbidity and Greenhouse Gas Emission Per Unit of Electricity Produced

Source (% of world use, 2007)	Deaths per terawatt-hour	Tons of greenhouse gas emissions per gigawatt-hour (life)
Coal (42%)	161 (U.S. average is 15)	800–1,400
Gas (21%)	4	300–500
Hydro (16%)	0.1 (Europe)	Small–100
Wind (<1%)	0.15	Small–50
Nuclear (14%)	0.04	Small–50

Source: Edward D. Blandford and Michael M. May, "Lessons Learned from Lessons 'Learned': The Evolution of Nuclear Power Safety after Accidents and Near-Accidents", American Academy of Arts and Sciences, 2012, p. 23.

3. Edward D. Blandford and Michael M. May, "Lessons Learned from 'Lessons Learned': The Evolution of Nuclear Power Safety after Accidents and Near-Accidents", American Academy of Arts and Sciences, 2012, p. 23.
4. Ibid., p. 23.

The low morbidity in the nuclear sector is mainly owing to the fact that the same amount of electricity can be obtained from about 200 to 300 tons of uranium ore as from 3 to 4 million tons of coal or similarly large quantities of gas or oil. Moreover, no combustion is involved in nuclear energy generation; rather, smaller tonnage is mined, transported, and processed in comparison to other sources. However, the relative costs and benefits of nuclear energy have remained a subject of heated debate. While critics argue that nuclear energy is not only dangerous but also unnecessary for tackling climate change, supporters claim that the risks are small and that abandoning the nuclear source would make an already huge challenge even more difficult and expensive.

There is a lot of uncertainty about the cost of nuclear power compared to the alternatives and these uncertainties increase as one looks towards the future.

Undoubtedly, there is a lot of uncertainty about the cost of nuclear power compared to the alternatives and these uncertainties increase as one looks towards the future.[5] Decarbonising electric power will be critical for solving climate change concerns. The world will need twice as much electricity in 2050 as it does today. As other alternatives are depleting or not up to the mark, nuclear power has the potential to address both the concerns provided the uncertainties are clarified at the earliest. The Committee on Climate Change, UK, in a study has estimated the cost of nuclear energy as falling somewhere above 'low cost' options such as onshore wind, mini-hydro and some bio-fuels, but below 'expensive' options such as offshore wind and Carbon Capture and Storage (CCS).[6] The report asserts that deep reductions in levelised costs are possible if the policy, regulatory, and licensing regimes are supportive.[7] A lot more needs to be accomplished in these matters to clear much of the air which will automatically facilitate greater social acceptance of nuclear power.

5. "Is Nuclear Power Necessary for Solving Climate Change?", *The Guardian*, December 21, 2012.
6. "Costs of Low-Carbon Generation Technologies", Committee on Climate Change, London, May 2011, http://hmccc.s3.amazonaws.com/Renewables%20Review/MML%20final%20report%20for%20CCC%209%20may%202011.pdf
7. Ibid., pp. 7-12.

However, it is necessary to keep in mind that accidents or incidents may occur in the nuclear industry like in any other industry; the chances of misuse of nuclear knowhow are likely to remain; and the fear of nuclear technology falling into terrorists' hands will persist. All this does not mean that there is no future role whatsoever for nuclear technology or nuclear energy. Partly, the fear of radioactive mutated monsters generated by anti-nuclear propaganda has turned the atomic dreams, and atomic nightmares into "one of the most powerful complexes of images ever created outside of religions".[8] And there is no easy solution to these fears except bringing abundant benefits out of nuclear energy to the people as early as possible, while addressing their concerns wholeheartedly.

THREAT TRIANGLE

Especially in the aftermath of 9/11 and 3/11, safety, security, and safeguarding of nuclear material and technology has been a major global concern. Many assume that "catastrophic nuclear accidents are inevitable, because designers and risk modelers cannot envision all possible ways in which complex systems can fail"[9] as there is no 'absolute safety'; security measures can become obsolete as time passes; and misuse of technology is inevitable. Undoubtedly, "assuring safety is hard work" and "an obligation that demands constant attention".[10] However, to fathom "how much safe is safe enough" is probably the most stupendous task in the security discourse. There is also the view that the risk is inherent in every industrial activity, including nuclear, but it can be made quite small. With proper management techniques, the security risks, proliferation hazards, and safety risks can be minimised to the extent that the benefits can outweigh the inherent risks. Noteworthy safety-security lapses continue to occur in every industrial sector, including at Nuclear Power Plants (NPPs) around the globe, even in countries with extensive operational experience and strong regulatory capabilities. The world has not abandoned those industrial projects—rather

8. P.D. Smith, "*The Rise of Nuclear Fear* by Spencer R. Weart – Review", *The Guardian*, April 3, 2012.
9. M.V. Ramana, "Beyond Our Imagination: Fukushima and the Problem of Assessing Risk", *The Bulletin of the Atomic Scientists*, April 19, 2011.
10. Richard A. Meserve, "The Global Nuclear Safety Regime", *Daedalus*, Fall 2009, p. 102.

the focus has been to study what went wrong and try to fix it.

Today, the nuclear industry is "suffering from the cumulative impacts of the world economic crisis, the Fukushima disaster, ferocious competitors and its own planning and management difficulties."[11] Which way the nuclear energy discourse will move is a matter of conjecture. Taking the middle position, this study advocates that *safe nuclear power is possible and desirable*. This could be a reality by a balanced understanding of technology-society correlation – if technology is misunderstood, development is missed, and if technology is uncontrolled, civilisation is at stake. The imperative is to make this correlation even-handed or objective. However, when both sets of issues (the efficacy of nuclear power as a viable source of energy, and the threat to the nuclear industry) are clubbed together, as everyone tends to do, nuclear technology becomes the subject of myriad controversies.

First of all, it is to be kept in mind that the threat to the nuclear industry emanates largely from the nature of the strategic environment. 9/11 and terrorists activities have increased attention to ensure adequate security at nuclear installations. Clandestine nuclear programmes and technology transfer networks have warranted attention to ensure adequate safeguarding of nuclear materials. At the same time, nuclear accidents have long provided the justification for a particular emphasis on safe operations at nuclear power plants. The nuclear industry, therefore, is subject to intricacies and concerns of safety, security and safeguards. Safety is aimed at preventing accidents; security is aimed at preventing intentional acts that might harm the nuclear power plant or result in theft of nuclear materials; and safeguards are aimed at preventing the diversion of nuclear materials

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11. Mycle Schneider and Antony Froggatt, "The World Nuclear Industry Status Report 2012", July 2012, http://www.worldnuclearreport.org/IMG/pdf/2012MSC-WorldNuclearReport-EN-V2-LQ.pdf, p. 4.

for nuclear weapon purposes.[12]

Nuclear Safety: Like any other industrial enterprise, safety risks are inherent in every component of the nuclear industry: uranium mining, reprocessing, conversion, energy generation, waste management, and even at the decommissioning phase. According to the International Atomic Energy Agency (IAEA) *Safety Glossary*, nuclear safety denotes "the achievement of proper operating conditions, prevention of accidents or mitigation of accident consequences, resulting in protection of workers, the public and the environment from undue radiation hazards".[13] This suggests that safety evaluations focus on risks arising from unintended events initiated by natural phenomena (like earthquakes, tsunami, tornadoes, or flooding), internal hardware interruptions (such as fire, pipe breakage, or loss of electric power supply), or human mistakes (such as the incorrect application of procedures, or incorrect alignment of circuits). So, nuclear safety involves designing, construction and operating of nuclear facilities to protect against the accidental release of radioactive material to the workers, the public or the environment. It also includes the responsibility to respond effectively to an incident or accident to minimise the radiological and other consequences.[14] However, with adequate caution and management techniques, these can be effectively minimised.

Normally, every nuclear facility is designed and built to withstand a postulated accident (design-basis threat) without loss to the systems, structures and components necessary to ensure public health and safety.[15] To ensure this, the basic requirement is adequate infrastructure as well as commitment of the national government, the operator, regulator, vendor and other organisations, to achieve the best possible safety. This involves creation and application of excellent management, design and operation of the nuclear organisation strictly as per the guidelines laid down.

12. IAEA, "The Interface Between Safety and Security at Nuclear Power Plants", INSAG-24, 2010.
13. IAEA, "Nuclear Safety & Security", http://www-ns.iaea.org/standards/concepts-terms.asp; "Nuclear Security", http://www.iaea.org/Publications/Booklets/NuclearSecurity/ns0312.pdf
14. Mark Fitzpatrick, ed., "Nuclear Safety and Security", in *Preventing Nuclear Dangers in Southeast Asia and Australia*, *IISS Strategic Dossier*, 2009, p. 31.
15. Duyeon Kim and Jungmin Kang, "Where Nuclear Safety and Security Meet", *The Bulletin of the Atomic Scientists*, 68 (1), 2012, p. 87.

Normally, the "defence-in-depth" concept is employed within the nuclear safety arena to lessen the frequency of trigger events; to prevent them from leading to more severe events; and to mitigate the consequences, if they occur. In addition, there is nurturing of a national "nuclear safety culture" (safety values and behaviours modelled by its leaders and internalised by the members involved to make nuclear safety the overriding priority), an intangible concept based on a safety-conscious work environment, and collective responsibility to adhere to the safety principles is the cardinal virtue.[16] A variety of international legal instruments, including conventions and codes of conduct and the IAEA safety standards, supplemented by IAEA safety support programmes, and a global network of experts constitute the global nuclear safety regime.

Nuclear Security: In the IAEA statute and publications, the term "nuclear security" is often abbreviated to 'security'. However, a working definition of nuclear security, according to the IAEA *Safety Glossary*, is "the prevention and detection of, and response to, theft, sabotage, unauthorized access, illegal transfer or other malicious acts involving nuclear or other radioactive substances or their associated facilities".[17] To further amplify, one can demarcate nuclear security as certain responses to mainly four threats: (1) theft of nuclear material; (2) nuclear explosive devices manufactured using the stolen nuclear material; (3) dispersion of devices for radioactive material (dirty bombs); and (4) sabotage or destruction of nuclear power facilities or of radioactive material in transport.[18] Another type can be a combined disaster, in which opportunistic antagonists time their malicious activity to take advantage of natural disasters that weaken nuclear safety systems. The apparent lack of security in the immediate aftermath of the Fukushima meltdown highlighted the need for planning for such combined nuclear dangers.[19]

16. "Principles for a Strong Nuclear Safety Culture", November 2004 http://www.efcog.org/wg/ism_pmi/docs/Safety_Culture/Dec07/INPO%20PrinciplesForStrongNuclearSafetyCulture.pdf
17. IAEA, n. 13.
18. Tetsuya Endo, "Countries Planning to Introduce Nuclear Power Generation and the 3Ss: Making the 3Ss an International Standard", The Japan Institute of International Affairs, June 2009, p. 5.
19. Kim and Kang, n. 15, p. 90.

One can find a gradual expansion of concern from the physical security of nuclear material to the security of NPPs, technology, and knowhow.

All these aspects necessitate strict physical protection measures like guards, guns, limits on access to vital areas, and intelligence on adversaries to thwart their nefarious designs. With a sound management system and shared responsibility by operators and authorities, and confidentiality of information regarding the facility, unauthorised access can be prevented. Nuclear security, therefore, "deals with any activity or system that contributes to the protection of nuclear and high hazard radioactive materials from unauthorised access, theft, diversion or sabotage, including *inter alia* guarding, physical protection, facility design, personnel vetting, IT security, technical measures, etc."[20] According to a report, between 1972 and 2007, altogether 17 major terror attacks or acts of sabotage have been carried out against nuclear power plants although none of them resulted in an uncontrolled radioactive release.[21]

At the beginning of the nuclear age till the late 1950s, nuclear security was not specifically regarded as a matter of grave concern in comparison to nuclear safety and safeguards. However, during the 1960s and 1970s, nuclear security issues were first taken up from the perspective of the physical protection of nuclear material as, during the same period, there was a sharp rise in nuclear reactors transfers and nuclear energy production the world over. Therefore, in 1975, the IAEA brought out a recommendation (INFCIRC225, 1975), adopted as the Convention on the Physical Protection of Nuclear Material in 1977 as a legally binding document. With nuclear terrorism becoming a realistic scenario during the 1990s and more so after 9/11, nuclear security issues began to be examined in earnest.[22] One can find a gradual expansion of concern from the physical security of nuclear material to the security of NPPs, technology, and knowhow. Therefore, a comprehensive security structure encompassing

20. WINS, "An Integrated Approach to Nuclear Safety and Nuclear Security", World Institute for Nuclear Security (WINS), 2010, p. 3.
21. F. Steinhausler, "Countering Security Risks to Nuclear Power Plants", *Nuclear Power* (Session 5/No 4), International Symposium on the Peaceful Applications of Nuclear Technology in the GCC Countries, Jeddah 2008.
22. Endo, n. 18.

personnel, material, technology, knowhow and their movement is devised along with the legal obligations.

To manage security risks to nuclear installations, the method of 'vital area protection' is adopted. 'Vital area' is an area that contains vital equipment whose destruction or manipulation could endanger public health and safety by exposure to radiation. Normally the nuclear installations take into account the Design Basis Threat (DBT) and embed many security measures in the design itself as certain threats are predictable. The DBT concept is based on the assumption that terrorist acts show a considerable degree of predictability with regard to their method of attack as well as the scope of their criminal action. As a standard practice, site-specific DBTs are classified for security reasons. However, the major components of a DBT, taking into account the threat from both insiders and outsiders, are: (1) identification of the threat; (2) defending against potential attackers; (3) delaying the attackers until security reinforcements have arrived.[23]

To protect against intruders, a series of fences with various sensors and multiple CCTV cameras is installed on-site and at the site perimeter; and inspection of all persons and vehicles entering the site is carried out. To deal with the probable threats from the insiders, personnel reliability programmes are put in place, with criminal background checks and psychological tests of employees. Mock attacks on NPPs are planned and carried out to test the security readiness of the on-site security forces at successive intervals and sometimes without prior notice. After 9/11, the security arrangements in and around the NPPs have also been designed to defend against aerial attacks and cyber attacks. To address the threats from the air, no-fly zones and anti-aircraft guns, etc. have become an integral part of the security system. Defending against cyber terrorism is a complex endeavour. A tiny disk or hard drive is enough to execute a cyber terror plan even if the computer system in a plant is isolated from the internet. The primary objective of any cyber security programme is to protect the confidentiality, integrity and attributes of electronic data or computer systems and processes in a highly complex and integrated environment. Appropriate measures against cyber

23. Ibid.

attacks targeting the digital Information and Communication Technology (ICT) systems of nuclear plants, therefore, include detection, response, mitigation, recovery.[24] However, the global nuclear security regime is not as mature as the safety regime.[25] It comprises some international legal instruments, including conventions and codes of conduct and the IAEA Nuclear Security Series publications, and IAEA security services.

Nuclear Safeguards: As the same technologies, infrastructure and materials used for civilian applications are also used in the nuclear weapon programme, chances of their diversion leading to misuse is always apprehended. Safeguards measures, therefore, aim to prevent the diversion of nuclear technology and materials for nuclear weapon purposes. The first official reference to "safeguards" with respect to nuclear power can be found in the November 1945 Declaration on the Atomic Bomb by President Harry S. Truman and Prime Ministers C.R. Attlee and W.C Mackenzie King of the UK and Canada respectively. The "Atoms for Peace" speech to the UN General Assembly in December 1953 led to the creation of the IAEA in 1957 whose primary duty is to promote the peaceful use of nuclear energy and implementing of safeguards. The nuclear Non-Proliferation Treaty (NPT) and the IAEA constitute the core of the non-proliferation regime looking into nuclear safeguards issues.

However, the global nuclear non-proliferation regime today faces three intricate challenges: enforcement; a crisis of confidence; and the three "T's" – theft, trafficking and terrorism.[26] Non-compliance by countries like Iraq, North Korea, Libya, and Iran has greatly undermined confidence in the regime. Also, the regime contains a number of loopholes that are exploited by the state parties. A state can acquire all the elements of the nuclear fuel cycle as long as it declares them and subjects them to safeguards. But, on six months' notice, it may withdraw legally from the treaty on national security

24. Sitakanta Mishra, "Cyber Threat to Nuclear Installations", *Scholar Warrior*, Autumn 2012, pp. 111-112.
25. IAEA, INSAG, n. 12, p. 6.
26. House Hearing, 111 Congress, "Stopping the Spread of Nuclear Weapons, Countering Nuclear Terrorism: The NPT Review Conference and the Nuclear Security Summit", Hearing before the Committee on Foreign Affairs, House of Representatives, Second Session, April 21, 2010, Serial No. 111-90, http://www.gpo.gov/fdsys/pkg/CHRG-111hhrg56092/html/CHRG-111hhrg56092.htm

grounds and move immediately to acquire nuclear weapons, the way North Korea did.

Instances of nuclear material smuggling are on the rise and their slippage into the wrong hands would be disastrous.

Among various legal and technological procedures, the non-proliferation regime relies on inspections as the primary element in investigating any diversion of nuclear technology and material. The IAEA initially implemented certain provisions of safeguards and after the NPT came into force in 1970, it was given responsibility for full-scope safeguards under the NPT. In the 1990s, an Additional Protocol and supplementary measures were implemented to streamline the safeguards. In the safeguards agreements pursuant to the NPT, a state is required to establish and maintain a State System of Accounting and Control (SSAC) of nuclear material within its territory, jurisdiction or control.[27] However, instances of nuclear material smuggling are on the rise and their slippage into the wrong hands would be disastrous. The endeavour has been to put in place both legal obligations as well as technical measures to reduce the chances of diversion or misuse of nuclear materials. While many bilateral and multilateral non-proliferation regimes are in place, efforts are on to invent proliferation resistant reactors and fuel cycle.

The Intricate Interface: The trio – safety, security, and safeguards – represent specific aspects of the nuclear domain, symbolising an exclusive sphere of responsibilities, but they overlap in many respects. However, the three aspects have been regulated and managed traditionally in isolation from each other. While safety management has been the responsibility of operators, engineers, safety managers and scientists, ensuring security tends to be the responsibility of the security personnel with a different professional background and a range of competencies.

As all the three overlap considerably, the interface among them is extremely intricate. "As the security framework matures, safety and security obligations serve to reinforce each other. Measures related to non-proliferation

27. Sven Thorstensen, "Nuclear Material Accounting and Control: Coordinating Assistance to Newly Independent States", *IAEA BULLETIN*, 1/1995, p. 29.

(safeguards) also contribute to the overall goal of protecting public health and the environment…."[28] Especially, interconnectedness between safety-security, security-safeguards, and safeguards-safety denotes an intricate paradigm that is to be coherently addressed. To ensure a safe and secure nuclear project, better understanding of the three interfaces is necessary.

Firstly, the objective of all these three aspects is the same – protection of the people, society and environment. Such protection is achieved by preventing a large release of radioactive material. Second, as their spheres overlap, and are, therefore, mutually reinforcing, the principles to ensure protection and consequent elements or actions are common even though their implementation may differ. Thirdly, the philosophy applied to achieve the fundamental objectives of the three domains is similar. While nuclear security aims to follow the 'defence in-depth' philosophy by establishing a series of protective layers, nuclear safety strives to address 'design basis threats' by a comprehensive strategy for the defence of the facility to withstand a postulated event. The principle of optimisation of protection is common to both safety and security and based on the idea that radiation risks must be kept as low as reasonably achievable (ALARA).[29] Also the steps taken to provide protection against malicious acts incorporate specific features to ensure physical protection, and rely on provisions that may have been installed for safety reasons. For example, nuclear plants are constructed with protective barriers of steel and reinforced concrete that serve both a security and a safety function.

There are many other arrangements that enhance both safety and security simultaneously. For example, the reactor containment serves to prevent release of radioactive material to the environment in the event of an accident, while simultaneously providing a robust structure that protects the reactor from a terrorist assault. Similarly, controls to limit access to vital areas not only serve a safety function by preventing or limiting exposure but also serve a security purpose by inhibiting unauthorised access by intruders. Especially, there are five elements that are central, and

28. Ibid.
29. IAEA, INSAG, n. 12, p. 3.

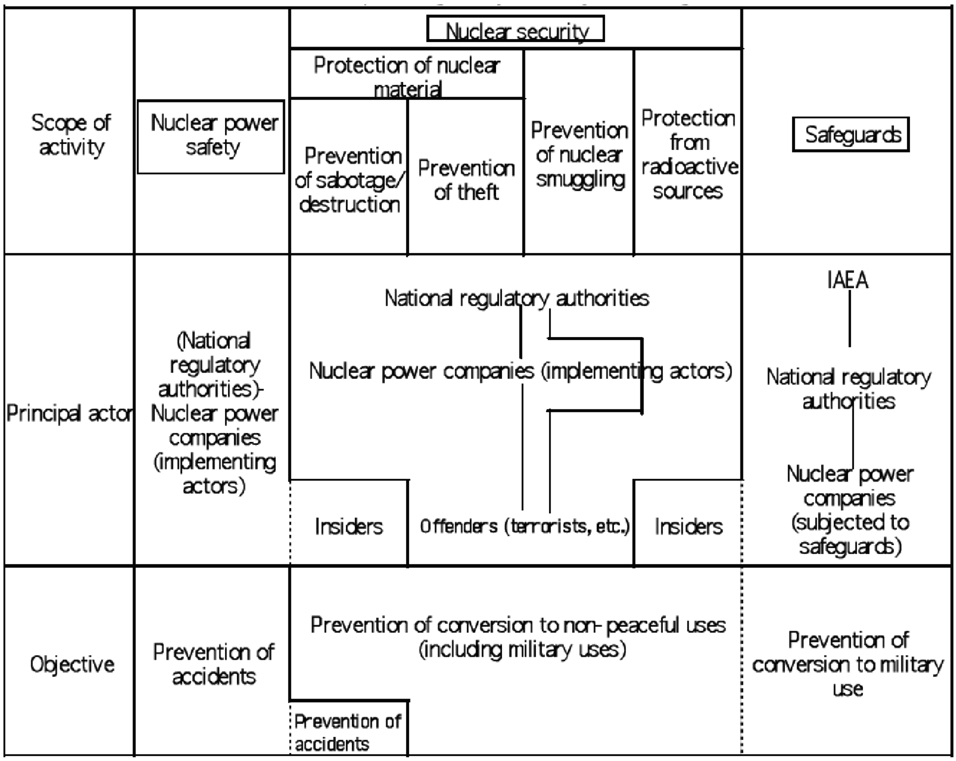
have direct applicability, to the nuclear security regime: (a) regularised assessments; (b) information sharing; (c) peer review; (d) reviews of the implementation of relevant international conventions; and (e) strong trade organisations.[30]

Further, "peace" and "safety" are the keywords for securing and regulating nuclear power. Preventing nuclear material and technology from diversion to military purposes or slippage into wrong hands constitutes another dimension of nuclear security, and is aimed to deter and detect unauthorised removal of nuclear material – to provide assurance that all nuclear material is accounted for. Therefore, safeguards measures enhance safety by preventing diversion and misuse of nuclear material, mainly relying on the methods of 'safeguards by design' and proliferation resistant technology. There are areas where safeguards and security can interact to improve effectiveness and efficacy in achieving their objectives like R&D and surveillance system, analysis capability (nuclear forensics), nuclear trade and illicit trafficking analysis, advisory missions, Information Technology (IT) security, quality management system, risk assessment and emergency response.[31]

Therefore, the interrelationship among the three spheres is straightforward: safeguards can be thought of as addressing "peace"; nuclear safety as addressing "safety"; and nuclear security as spanning both "peace" and "safety".[32] While nuclear security focusses on prevention, detection of, and response to, the theft of nuclear material that can be used for nuclear weapons or nuclear explosive devices (therefore, connected with "peace"), nuclear safety addresses the malicious intentions of terrorists. In other words, nuclear safeguards fundamentally target state actors, nuclear security focusses on terrorists, and nuclear safety covers engineering phenomena but all aim to ensure safe and secure nuclear power.

30. Kenneth Luongo, Sharon Squassoni, Joel Wit, "Integrating Nuclear Safety and Security: Policy Recommendations", CSIS, December 13, 2011.
31. Kenji Murakami, "Nuclear Safeguards Concepts, Requirements, and Principles Applicable to Nuclear Security", Nuclear Security Governance Experts Group, July 2012, p. 9.
32. Endo, n. 18, p. 6.

Fig 1: Interrelationship Among Safety, Security, and Safeguards



Source: "Countries Planning to Introduce Nuclear Power Generation and the 3Ss: Making the 3Ss an International Standard", http://icnnd.org/Documents/endo_3s_int_standard.pdf, p. 8.

THE DILEMMA

Taking into account the increasing number of nuclear reactors under construction in various parts of the world, one may assume that problems related to safety, security and safeguards are inevitable. Since the three spheres overlap considerably, the importance of a coordinated approach to nuclear safety, security and safeguards with the objective to have greater uniformity is oft-emphasised. However, there exist some tensions between each of these aspects that may lead to a dilemma if they are frantically integrated. For example, nuclear safety measures rely on transparency and a culture that strongly encourages an open review of past mistakes; nuclear security, on the other hand, relies on confidentiality of information that may be of use to an adversary.[33] Nuclear security relies on limiting access to vital areas of plants, while an effective emergency response may require immediate access by nuclear safety personnel and emergency responders. For example, the introduction of delay barriers for security reasons can limit rapid access to respond to a safety event or can limit emergency egress by plant personnel. Security considerations might serve to bar plant personnel from certain areas to the facility in the event of an attack that might need to be accessed for safety reasons. In the same way, certain safeguards are considered confidential, whereas nuclear security, by its very nature, requires the maintenance of secrecy and, thus, is not suited to public disclosure. The focus on sovereignty with respect to nuclear security is especially highlighted in the area of information security. Therefore, "information exchanges and peer reviews have not played a large role in the nuclear security regime" so far.[34]

Moreover, the three regimes are at different stages of their evolution. While the nuclear safety regime encompasses a broad spectrum and a long history, the nuclear security regime has a shorter history and the security culture has not matured as much as the safety culture. The IAEA security guidance has been developed but is viewed as somewhat less comprehensive/mature than the counterpart safety standards. The fact is, nuclear safety and security have developed along different trajectories in the last few decades. The nuclear safety regime, comprising national laws and regulations, voluntary international agreements and conventions, has matured relatively quickly following the Three Mile Island and Chernobyl incidents. The nuclear security regime has advanced largely in response to the 9/11 attacks. The nuclear safeguards regime, on the other hand, is not yet universal and the non-proliferation regime is marred by numerous controversies. Above all, the implementation of nuclear safety and security measures is largely voluntary and national in nature.

Therefore, strengthening the safety-security-safeguards interface is a complex undertaking. A security-heightened approach, though necessary,

33. Fitzpatrick, n. 14, pp. 31-32.
34. Luongo, n. 30.

would not suffice to address all safety threats. Similarly, a culture of nuclear safety practice is necessary, but that alone cannot protect people or the environment from malicious acts. What is needed, therefore, is a *new strategic paradigm* in the development and expansion of nuclear energy based on the 3S (Safety, Security, and Safeguards).[35] An international initiative on the 3S-based nuclear energy infrastructure was first proposed in the G8 Summit 2008 at Chitose, Hokkaido, Japan. The G8 Initiative on Nuclear Energy Infrastructure recognised "the need to establish common understanding that implementation of non-proliferation/safeguards, safety and security (3S) is indispensible for the use of nuclear energy."[36] Against this background, the G8 Initiative, aimed at raising awareness of the importance of 3S worldwide and assisting the countries concerned in developing the 3S, was discussed in the Nuclear Safety and Security Group (NSSG), established at the Kananaskis Summit, and found broad support.[37]

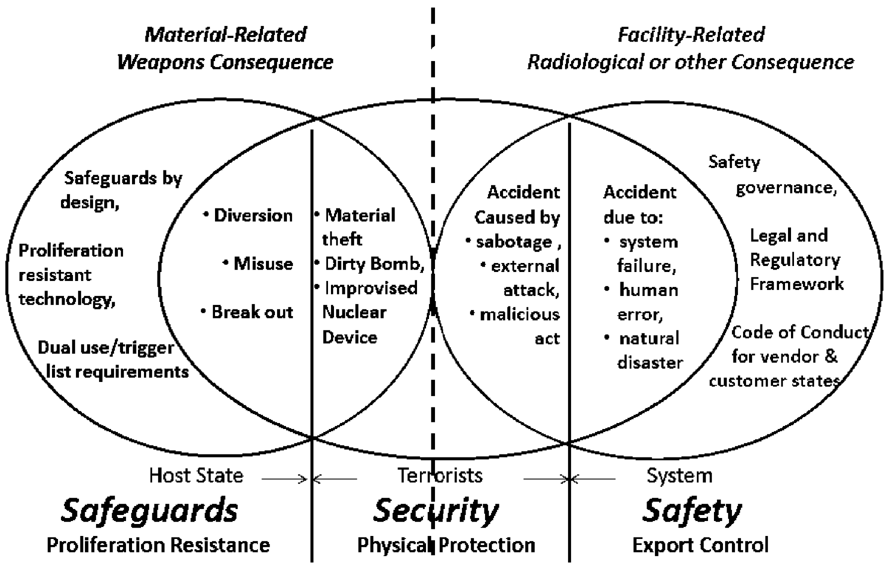
The first Nuclear Security Summit in Washington DC (2010) focussed on the theme of securing nuclear materials and preventing illicit nuclear trafficking and nuclear terrorism. Therefore, it aimed at a 2S approach by integrating safeguards and security measures on nuclear materials. The 2012 Nuclear Security Summit at Seoul focussed on nuclear security and safety to address facility related radiological consequences.

The Seoul Communiqué at best renewed the political commitments generated from the 2010 Washington Summit "to work toward strengthening nuclear security, reducing the threat of nuclear terrorism, and preventing terrorists, criminals, or other unauthorized actors from acquiring nuclear materials."[38] The summit stressed the states' fundamental responsibility to maintain effective security of all nuclear material through measures which would not hamper their right to develop and utilise nuclear energy for

35. Jor-Shan Choi, "An Integrated Approach to Nuclear Safety and Security: In the Context of 3S (Safety, Security, and Safeguards)", http://www.jaea.go.jp/04/np/activity/2011-12-08/2011-12-08-22.pdf.
36. "Report of the Nuclear Safety and Security Group", G8 Summit, 2008, Hokkaido, Toyako, May 29, 2008, p. 3.
37. Ibid.
38. "Seoul Communiqué, 2012 Seoul Nuclear Security Summit", http://www.thenuclearsecuritysummit.org/userfiles/Seoul%20Communique_FINAL.pdf

peaceful purposes. The summit also urged for universal adherence and support to multilateral instruments like the Physical Protection of Nuclear Material (CPPNM), International Convention for the Suppression of Acts of Nuclear Terrorism (ICSANT), Global Initiative to Combat Nuclear Terrorism (GICNT), and Global Partnership against the Spread of Weapons and Materials of Mass Destruction.[39] Moreover, the leader of the summit recognised the importance of 'capacity building' as fundamental to promote a strong nuclear security culture and "maintain robust communication and coordination of activities". In this regard, it reaffirmed "the need for various public diplomacy and outreach efforts to enhance public awareness of actions taken and capacities built to address threats to nuclear security, including the threat of nuclear terrorism".

Fig 2: International Initiative on 3S-based Nuclear Energy Infrastructure (Proposed first in the G8 Summit 2008, Japan)



Source: Jor-Shan Choi, http://www.jaea.go.jp/04/np/activity/2011-12-08/2011-12-08-22.pdf

39. Ibid.

The best practices of different countries can be shared and utilised for safe and secure nuclear energy production globally.

GLOBAL NUCLEAR GOVERNANCE

A cursory look at the concerns raised and initiatives undertaken bring one the impression that the world is standing at a "nuclear turning point".[40] A resolve seems to be emerging to strengthen the global concerns to pursue the objectives of reducing the nuclear threat by building a tangible foundation[41] through the Nuclear Security Summits (NSS) which strive to balance national sovereignty vis-à-vis international obligations of nation-states in the sphere of global nuclear governance.

So far, atomic power has remained the exclusive sphere of the state domain and the 'responsibility for nuclear safety rests with the state'. For the last few decades, there has been increasing fear of non-state actors gaining access to nuclear technology. Therefore, the issue of safety and security of nuclear technology has become more acute. Secondly, a nuclear disaster respects no national border and radiation can travel far, affecting surrounding nations. The nuclear industry, therefore, needs to be based on consensus and cooperation, taking into account the different stakeholders. Thirdly, the best practices of different countries can be shared and utilised for safe and secure nuclear energy production globally. All these indicate an effective global *nuclear governance* architecture regulating all aspects of the nuclear energy process. This is increasingly being shared among states, inter-governmental and non-state actors through standards and best practices that play complementary and parallel roles in ensuring nuclear safety, security and safeguards in the last two NSS.[42]

In the current international political lexicon, 'nuclear governance' refers to "the web of international treaties, agreements, regulatory regimes, organizations and agencies, monitoring and verification mechanisms and

40. Bates Gill, "Good Nuclear Governance and Nuclear Security Challenges, Implications, and Responses", *IFANS Review*, 18 (2): 2.
41. Ji Yeon Jung, "Prospects of the Seoul Nuclear Security Summit, 2012", *Defence and Diplomacy*, January-March 2012, pp. 69-70.
42. Ramesh Thakur, "The Global Governance Architecture of Nuclear Security", *Policy Analysis Brief*, Stanley Foundation, March 2013, p. 9.

supplementary arrangements that help determine the way that the peaceful uses of nuclear energy, notably the generation of nuclear electricity, is governed".[43] They exist at the international, regional and sub-regional or bilateral levels and largely depend on national implementation arrangements which ensure that each country fulfills its obligations in the nuclear field. It is a collaborative enterprise involving many players at various levels that indeed emphasises on a holistic approach.[44]

The current status of global nuclear governance is linked mainly to various regimes in its nuclear safety, security and non-proliferation arena. The 1994 Convention on Nuclear Safety (CNS) that entered into force in October 1996 is the most important legally-binding instrument in the nuclear safety field. Though the treaty applies to land-based civilian nuclear power reactors, radioactive waste management, and storage of spent fuel, it excludes other nuclear fuel cycle facilities for fuel fabrication, uranium conversion and enrichment, and reprocessing. In fact, fuel cycle facilities face unique nuclear safety challenges which need urgent attention. Also, the CNS has no monitoring, verification or compliance system and no penalties for non-compliance. It is alleged that the CNS suffers from a lack of openness and transparency, making it impossible for outsiders to truly assess the system's effectiveness.[45]

The IAEA is considered as the global hub of nuclear safety and security. It acts as the secretariat for all the new safety-related conventions, and sets and promotes safety standards, safety advisory missions and management of peer review processes. It also establishes guidelines and codes of conduct and provides significant advice and assistance to member states on all nuclear-related matters. The Operational Safety Review Teams (OSART) programme is designed to aid states in improving the operational safety of their nuclear plants essentially through the process of peer review. The IAEA's Integrated Regulatory Review Service (IRRS) provides advice and assistance to enhance the effectiveness of regulatory infrastructure for both

43. Trevor Findlay, *Nuclear Energy and Global Governance* (London: Routledge, 2011), pp. 2-3.
44. Ibid., p. 3.
45. Ibid., p. 106.

safety and security. The IAEA Incident Reporting System (IRS) collects information from participating states' national regulators on unusual events in nuclear power plants, assesses, analyses and extends feedback to operators to prevent similar occurrences at other plants. However, all these do not legally oblige states to implement IAEA standards. Many countries do not even report to the IAEA. The question arises as to whether such standards and practices should be made legally binding and compliance with them verified by international inspectors, as in the case of nuclear safeguards. In 2000, the IAEA initiated the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) and released the INPRO methodology. However, the boundary between the capacity to produce nuclear energy and nuclear weapons is thin, therefore, difficult to monitor. Countries, by availing all international cooperation on civilian nuclear technology, can also attain the capability to produce nuclear weapons at short notice. North Korea, after availing multilateral nuclear technology support through the NPT, withdrew from the regime and opted for nuclear weapons. It has been apprehended for long that the spread of nuclear weapons to more states increases the chance of their misuse.

Many other international bodies have also undertaken the responsibility of ensuring nuclear safety like the World Association of Nuclear Operators (WANO), Nuclear Energy Agency (NEA), World Nuclear Association (WNA) European Atomic Energy Community (Euratom) and European Commission (EC). Especially, WANO runs a peer review system to facilitate "communication, comparison and emulation" and technical support missions among its members in order to maximise safety and reliability. The NEA focusses on research and information exchange in selected areas like nuclear sciences, safety, regulation, waste management, technical and economic studies, nuclear law and radiation protection. The Euratom helps promote nuclear safety through the cultivation of common views and by identifying best practices. The European Nuclear Safety Regulators Group (ENSREG) is the focal point of cooperation between European regulators and intends to lead to continuous improvement in nuclear safety, especially in new reactors.

The oldest but least understood legal regime fostering nuclear safety is the 'liability' one that emerged in the 1960s. This is the most important legal mechanism by which an operator can be held internationally accountable for a nuclear accident that causes trans-boundary hazards. Also, it aims to sustain public confidence in nuclear energy by ensuring adequate compensation to those harmed if an accident occurs. While imposing responsibility on operators to run the reactors safely, the regime provides stronger legal protection against unlimited liability for vendors that operate outside their own countries.

However, the liability regime has remained "paradoxical" and "less welcome" for various reasons.[46] It is alleged that it reduces the incentive for pursuing nuclear safety as it is based on the idea that the operator is ultimately responsible for the safety of its reactors. As the cost of liability insurance is not internalised, it provides a small but hidden subsidy to the nuclear industry, making it cheaper than it normally would be. Further, the liability regime has become complex as it is based on two separate international legal frameworks. The oldest is the Paris/Brussels framework, established under the auspices of the Organisation for Economic Cooperation and Development (OECD)/NEA, covering the OECD members. The Vienna framework, under the IAEA auspices, was intended to be universal by providing the framework for a global regime. The 1997 Protocol to Amend the Vienna Convention and the 1997 Convention on Supplementary Compensation for Nuclear Damage are two attempts to modernise the regime. The Convention Relating to Civil Liability in the Field of Maritime Carriage of Nuclear Material, 1971, deals with the liability issue with nuclear operators who transport nuclear material. More importantly, it has been marked that states have been remarkably reluctant to become parties to the liability conventions and protocols. According to different studies, fewer than half of the world's nuclear power plants are currently covered by the regime and the largest civil nuclear programmes

46. Ibid., p. 124.

have stayed away, providing disincentives for other states to join in.[47]

The nuclear global governance, especially on the security aspects and the regime thereof, is nowhere near as extensive, advanced or entrenched as the regime for nuclear safety governance is. Comparatively, there is less collaboration between nuclear plant operators worldwide in this sphere. Practically, there is no peer review as there exists an abiding sense that nuclear security is too sensitive an issue to be subject to global governance. In fact, "the pervasive secrecy surrounding nuclear security means that no global mechanism is in place to identify the worst security performers and help them come up to the level of the best performers".[48] Even the treaties and conventions that exist are laden with many handicaps that are challenging to address. The CPPNM (1980) strives to commit states to ensure nuclear material protection and organise review conferences every five years to assess the implementation of the convention as a whole. However, it does not focus on the compliance of individual parties. There is no peer review mechanism, nor does the IAEA have any particular role beyond transmitting information about national contact points.[49] An amendment to the convention was brought in 1998 to extend its ambit to domestic use, storage and transport aspects of nuclear activities. However, the amendment is not yet in force. In the same manner, the ICSANT entered into force in July 2007 and as of 2010, there were only 63 state parties and 115 signatories. It also does not have any monitoring, verification or compliance provisions or system of peer review, accountability or review meetings. The Security Council Resolution 1540 is a valuable and novel addition to global nuclear governance, but even its compliance and implementation have been "slow and uneven".[50]

47. Ann MacLachlan, "US Ratification Boosts Plan for International Nuclear Liability", *Nucleonics Week*, March 19, 2008; Johan Rautenbach, Wolfram Tonhauser and Anthony Wetherall, "Overview of the International Legal Framework Governing the Safe and Peaceful Uses of Nuclear Energy – Some Practical Steps", *International Nuclear Law in the Post-Chernobyl Period*, joint report by OECD/NEA and IAEA, 2006.

48.. Roger Howsley, "The World Institute for Nuclear Security: Filling a Gap in the Global Nuclear Regime", *Innovations*, vol. 4, no. 4, Fall 2009, p. 204.

49. Findlay, n. 43, p. 131.

50. Stanley Foundation, "Implementing UNSCR 1540: Next Steps Towards Preventing WMD Terrorism", *Policy Memo*, December 18, 2009, www.stanleyfoundation.org/publications/policy_memo/ImplementUNSCR15401209PM.pdf.

The global non-proliferation regime is comparatively more binding and relies on the compliance and verification process. Though the NPT has managed to restrict the number of nuclear weapon states to within ten, serious cases of non-compliance have undermined its credibility over the years. Successive Review Conferences have been forums of contention, and without tangible outcomes. Article VI of the treaty prescribes "negotiations in good faith" for all NPT parties to achieve nuclear disarmament; however, no significant step has been undertaken in this regard by any state-party yet. The IAEA safeguards framework has been increasingly authoritative and intrusive. At the same time, it could only monitor and inspect materials and facilities formally declared to it by the parties. There are reports saying that at least 24 states have not complied with their obligation to have a comprehensive safeguards agreement. As of December 2009, 93 states had an Additional Protocol in force, 34 had signed one and another eight countries' agreements had been approved by the IAEA Board of Governors (BOG).[51] Iran's clandestine nuclear weapons programme brings home the fact that the old safeguards system failed to detect its almost 20 years of non-compliance and, therefore, was inadequate. The widely-proclaimed strengthened safeguards arrangements, including the Additional Protocol, are still viewed to leave space for non-detection of undeclared facilities. The IAEA is viewed to be away from the "anytime, anywhere" verification capability and the "special inspection of cases" remains a highly politicised option within the BOG.

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Informal non-proliferation arrangements have emerged in the last few decades, sometimes supplementing the NPT and sometimes in reaction to its loopholes. The Zangger Committee and the Nuclear Suppliers Group (NSG) are multilateral arrangements that strive to restrict and monitor nuclear technology flow. However, their role has been criticised by many as "they breach the spirit if not the letter of states' inalienable right to the

51. Findlay, n. 43, p. 146.

peaceful uses of nuclear technology under the NPT". They seem to remain as "political lightning rods", therefore, the question arises whether these frameworks can ever be integrated into the formal structures of the IAEA.[52]

Three other relatively recent frameworks are the Proliferation Security Initiative (PSI), Global Nuclear Energy Partnership (GNEP) and Nuclear Security Summit (NSC). The PSI, which aims to interdict WMD technologies, started in 2003 and a growing number of countries are becoming its members. However, China objects to the PSI, regarding it as a threat to the Law of the Sea and interdiction of dual use technologies. The GNEP, while promoting civilian nuclear applications through the highest non-proliferation standards, aims to develop 'proliferation resistant' technology which is yet to be developed. The two NSCs have been successful to a certain extent in highlighting the imperatives of nuclear security and the substantive measures to be undertaken. However, there is considerable dilemma on how to reconcile national sovereignty with global responsibility to meet nuclear security objectives. It is really worrisome as some countries do not recognise the nuclear threat at all and even countries that do recognise the threat, may not recognise its full scope.[53]

Examining the contemporary harsh realities, Graham Allison says, "It is hard to avoid the conclusion that, on our present trajectory, the likelihood of a nuclear avalanche is greater than the prospect of reaching the peak".[54] While Iran and North Korea have produced enough nuclear material, Pakistan, a troubled state, is hurrying to expand its inventory. According to the IAEA Illicit Trafficking Data Base, from January 1993 to December, 2012, a total of 2,331 incidents was reported out of which 419 involved unauthorised possession and related criminal activities.[55] Unless and until "a brand-new innovative design, or architecture, based on long range views

52. Ibid., p. 151.
53. "Global Dialogue on Nuclear Security Priorities", Rapporteur's Report, Airlie Centre, Virginia, August 9, 2012, http://www.nti.org/media/pdfs/1st_Global_Dialogue_Rapporteurs_Report_July_2012.pdf?_=1353368765
54. Graham Allison, "Obama's Nuclear Vision – or Illusion?", *The Boston Globe*, April 5, 2013, http://www.bostonglobe.com/opinion/2013/04/04/obama-nuclear-vision-illusion/aj3Bn8W1iPZ5so00LdgPHP/story.html
55. IAEA, "IAEA Incident and Trafficking Database (ITDB)", http://www-ns.iaea.org/downloads/security/itdb-fact-sheet.pdf

and shared understanding of risks and their transversal impacts"[56], which the NSS is aiming to for, is put in place within a specific timeframe, the nuclear industry would only inch towards doomsday.

Many other regional and bilateral security frameworks like Nuclear Weapon-Free Zones and non-attack of nuclear installations seem to have been effective in certain cases. One nuclear weapon-free zone treaty – the African Nuclear Weapon-Free Zone Treaty (ANWFZ), known as the Treaty of Pelindaba – contains provision for ensuring the physical security of nuclear materials. It extends to the entire African continent and bans attacks on nuclear facilities. The treaty facilitates exchanges of information, consultations and compliance with the treaty obligations. Similarly, in South Asia, India and Pakistan have signed the treaty on Non-Attack on Each Other's Nuclear Facilities. The treaty was drafted in 1988, signed by the Pakistani Prime Minister Benazir Bhutto and her Indian counterpart, Rajiv Gandhi, on December 21, 1988, and entered into force in January 1991.[57] This obliges each party to refrain from undertaking, encouraging, or participating in, directly or indirectly, any action aimed at causing destruction or damage to any nuclear installation or facility in either country. It specifies each party to inform the other of the precise locations (latitude and longitude) of nuclear installations and facilities by January 1 of each year and whenever there is any change. For the last two decades, both countries have maintained the sanctity of the treaty and it has remained a significant nuclear (security) Confidence Building Measure (CBM) between them.

Most critical to global nuclear governance is the **role of national nuclear regulators.** They comprise the channel through which global governance norms, treaty obligations and recommended standards are implemented. A clear-cut separation of responsibilities between the nuclear regulatory and promoting agency is prescribed for strict and unbiased implementation

56. Irma Arguello, "Basis of a New Global Order for Nuclear Security", March 2012, http://www.nsgeg.org/Basis%20of%20a%20New%20Global%20Order%20for%20Nuclear%20Security%20-%20Irma%20Arguello.pdf
57. *Agreement between India and Pakistan on the Prohibition of Attack Against Nuclear Installations and Facilities (India-Pakistan Non-Attack Agreement)*, http://cns.miis.edu/inventory/pdfs/aptindpak.pdf

To utilise the best practices and benefit from each other's experiences, the effort has been to establish cooperation among nuclear regulators across the globe.

of safety standards. Having a regulatory body too close to organisations that promote nuclear projects is not healthy for the fact that it may compromise on implementation of safety rules and procedures. It is alleged that regulatory bodies in Brazil, India and South Africa are more proximate to the promoting agency. However, to utilise the best practices and benefit from each other's experiences, the effort has been to establish cooperation among nuclear regulators across the globe. There are now many such forums that facilitate interaction and cooperation. For example, the Network of Regulators of Countries with Small Nuclear Programmes (NERS); CANDU Senior Regulators; Cooperation Forum of State Nuclear Safety Authorities of Countries which operate WWER Reactors; and European Nuclear Safety Regulatory Group (ENSREG). The International Nuclear Regulators Association (INRA) established in 1997, having 31 regulators as its members provides a periodic forum to discuss nuclear safety and collective strategy. However, there is no universal international organisation that encompasses all regulators worldwide.

BALANCING SOVEREIGNTY WITH RESPONSIBILITY

Nuclear safety and security comprises a sovereign responsibility but only individual state determination of standards and their implementation is not enough. Strengthened international cooperation and accountability are urgent for early detection, prevention of attack, theft, sabotage and accidents involving nuclear material. For this to be achieved, "threat awareness" needs to be understood globally, at least, the "base level awareness." The goal is not only good global governance but "effective nuclear security implemented at all sites where it is needed." Global governance is "one tool to move toward that goal but not the only tool."

In case the global governance is in contradiction with the national responsibility, the necessity is a fine balancing of sovereignty with international responsibility of nation-states so that both are served simultaneously. On the other hand, extremely strict guidelines/standards to integrate the three spheres when a country newly introduces nuclear power generation may prove impractical. So, all standards should be limited to the minimum necessary. More importantly, instead of leaving the nomenclature of standards in the domain of individual states, it would be preferable to have the IAEA develop these standards.

To emphasise the need for a global response and national accountability, Senator Sam Nunn has identified the three biggest challenges to global nuclear safety and security initiatives today that need to be addressed urgently: (a) the state that does not recognise the threat of nuclear terrorism; (b) the state that does not take protective action; (c) the state that is complacent.[58] A collective responsibility for a "more robust, effective, and flexible" nuclear management system is the need of the hour. As the current achievements are not necessarily faring much better, the nuclear industry has not been able to obtain a wide range of public support.[59] In the meantime, nuclear disasters may occur, giving rise to further 'nuclear fear'. Realistically, every defence is time critical and can deteriorate as time passes. Therefore, the *nuclear defence* architecture that encompasses safety, security and safeguards, must be structured beyond design-basis threats, taking into account the intricacies of technical interfaces, professional integrity, social psychology, national obligations, and international collaborations.

58. Sam Nunn, "Remarks at the Global Dialogue on Nuclear Security Priorities", http://www.nti.org/analysis/speeches/remarks-global-dialogue-nuclear-security-priorities/, July 23, 2012.
59. Atsuyuki Suzuki, "Toward a Robust Nuclear Management System", *Daedalus*, Winter 2010, p. 82.