SANDIA REPORT
SAND2020-10916
Printed October 2020

Sandia National Laboratories

Nuclear Security Governance in India: Institutions, Instruments, and Culture (2019)

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ABSTRACT

There is an emerging consciousness in India of the importance of nuclear security and safety. Motivated by a combination of rapid growth in its civil nuclear sector, heightened scrutiny of recent nuclear accidents around the world, and the deteriorating regional security environment, India has pushed to adopt measures to strengthen and enhance its nuclear security and safety governance structures. India recognizes that the various recent global nuclear security initiatives are in its own best interest and has been an enthusiastic participant in the Nuclear Security Summit process. Today, India demonstrates a greater willingness to showcase its nuclear security arrangements before the public and has undertaken many institutional, legal, and operational reforms to maintain international regime compliance.

This study takes a comprehensive look at India's approach to nuclear security and critically examines the physical security measures the country has put in place. Particular focus is placed on the evolution and strengths, as well as weaknesses, of the country's nuclear security institutions, instruments, practices, and culture. Given that the strengthening of India's nuclear security governance is an ongoing endeavor, the paper also puts forward a number of policy recommendations.

ACKNOWLEDGEMENTS

In the process of conducting this study, we have accumulated a series of intellectual and professional debts. At the outset, we wish to thank Adriane Littlefield and Amir Mohagheghi, Managers of the Cooperative Monitoring Center, Sandia National Laboratories, for providing us with a truly enabling and encouraging atmosphere in which to carry out this research. We are particularly grateful to Adam David Williams and Adriane Littlefield for their consistent support, guidance, and inspiration which helped us to formulate and streamline our arguments and findings. We are also thankful for the generous feedback and advice extended by Thomas Ciccateri, David Betsill, Eric Wallace, and Shannon Abbott.

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> "Nuclear terrorism and clandestine proliferation continue to pose a serious threat to international security. India fully shares the continuing global concern on possible breaches of nuclear security."
>
> Plenary Statement by External Affairs Minister Salman Khurshid at the Nuclear Security Summit, 2014.

India has significant reasons to ensure stringent safe-keeping of its nuclear infrastructure. The deteriorating regional security environment, clandestine proliferation and thriving terror and smuggling networks in the neighborhood, and, above all, the unique nature of its nuclear program necessitates nuclear security in India to be a priority. India is conscious of the fact that credible threats to nuclear infrastructure exist; consequently, in coordination with international agencies and stakeholders, it has undertaken several security measures to strengthen its nuclear security system. Over the years, India has nurtured a comprehensive security arrangement in and around its nuclear infrastructure. While India has traditionally been guarded about publicizing its established nuclear safety and security structures, over the past decade or so—particularly since the country's integration into the global nuclear order and its participation in the Nuclear Security Summit (NSS) process—India has released several official documents and issued clarifications to showcase to the international community that it has been steadfast in securing its nuclear facilities and materials. Although significant progress has been made, there exists ample scope for further improvements in all aspects relating to nuclear security governance in the county.

India's history with the international nuclear order has evolved over time. Initially, India was engaged in nuclear disarmament activism, frequently proposing an end to nuclear testing, and was instrumental in the establishment of the International Atomic Energy Agency (IAEA). After its 1974 nuclear test, however, India was denied nuclear technology and material for more than three decades under an international embargo. The end of this moratorium came in 2005, when former US President George W. Bush and Indian Prime Minister Manmohan Singh began a sustained nuclear dialogue, culminating in an agreement facilitating nuclear cooperation. Today, India is well on its way to becoming an integral part of the international nuclear order. The Indo-US nuclear deal signed in October 2008 virtually ended India's isolation in the global nuclear order. In 2008, the Nuclear Suppliers Group (NSG), which normally prohibits its members from nuclear commerce with states that have not signed the Nuclear Non-proliferation Treaty (NPT), agreed on a special waiver for India. Today, New Delhi is eager to become a member of the NGS.

Currently, India has 22 operational reactors, with 6 more under construction. An additional 12 reactors have been approved for development and 16 more are planned based on cooperation with Russia, France, and the US. India is pursuing development of nuclear power plants by using a mix of indigenous Pressurized Heavy Water Reactors (PHWRs), Fast Breeder Reactors (FBRs), and Light Water Reactors (LWRs) based on foreign technical cooperation and fueled by imported enriched uranium. Beyond 2030, India's closed fuel cycle approach will focus on the widespread expansion of FBRs and thorium-based reactors. Its three-stage nuclear power program, based on the 'reprocess to reuse' strategy, strives to extract the maximum energy from the limited uranium resources, provide (arguably) inherent proliferation resistance, and ensure long-term energy security.

Besides energy production, India is pursuing comprehensive programs in radiation and isotope technologies for societal benefit in such areas as food preservation, development of superior mutant varieties of seeds/crops, nuclear medicine for diagnostics and radiation therapy, industrial radiography, and sewage and waste management. These areas have registered phenomenal growth. Many consignments containing radioactive materials are being transported within India, and many more transit through the country. In addition to the civilian application of nuclear resources, India has a strategic nuclear program based on the doctrinal posture of 'no-first-use' and 'second-strike' capability.

Owing to its past practice of mixing civil and strategic nuclear programs, nuclear security structure in India seems to have been intertwined. With the separation of India's civilian nuclear installations from its strategic program, India's nuclear security architecture has been streamlined. India's approach towards nuclear security constitutes five broad elements: (1) institutions; (2) technology; (3) nuclear security practice and culture; (4) governance; and (5) international cooperation. Though India's nuclear organizational structure is well designed, the relationship between the promoting agency (Department of Atomic Energy) and the regulatory agency (Atomic Energy Regulatory Board) requires a fresh look.

In India, security of nuclear facilities and material is the responsibility of the individual operators, which are government-owned. The Atomic Energy Regulatory Board (AERB) specifies the safety requirements through codes and guides, in which it lays down the necessary requirements. The primary responsibility for the safety of nuclear installations and material, and their transport and disposal, lie with the user/facilities. The AERB periodically issues and updates safety and security related documents for the concerned agencies to follow.

As the domains of nuclear security and nuclear safety in India have traditionally been considered as two sides of the same coin, the legislative framework and institutional architecture that were responsible for nuclear safety also catered to nuclear security considerations. Various rules have been established under the 1962 Atomic Energy Act such as: Atomic Energy (Working of Mines, Minerals and Handling of Prescribed Substance) Rules, 1984; Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987; Atomic Energy (Factories) Rules, 1996; Atomic Energy (Control of Irradiation of Food) Rules, 1996; Atomic Energy (Radiation Protection) Rules, 2004. In 2005, India passed the Weapons of Mass Destruction and Their Deliver Systems (Prohibition of Unlawful Activities) Act, 2005. These regulations address security related issues of India's nuclear program in different ways. Meanwhile, India has clearly been steadfast in its adherence to the instruments and norms stipulated by the global nuclear security regime.

The Indian nuclear security architecture is based on five pillars: (1) national legal provisions in consonance with IAEA guidelines; (2) oversight agency (AERB) that stipulates the standard operating procedures, or SOPs; (3) the security and intelligence agencies in charge of threat assessment and physical protection; (4) the human element (personnel) with the responsibility of oversight or observance; and (5) surveillance and detection technology for detection, delay, and response approach.

The physical protection system around Indian nuclear facilities is designed on the basis of their nuclear threat assessment, taking into account the Design Basis Threat and Beyond Design Basis Threat to create a layered protective envelope—consisting of inbuilt reactor security, material security, perimeter security, personnel reliability, material protection and accounting, transportation security, air and water front defense, emergency preparedness, legal provisions, and, in extreme situations, military protection.

The Central Industrial Security Force (CISF) oversees providing security to civilian nuclear facilities in the country. Each facility is guided by a CISF team headed by a commandant. At many sites, the CISF team is supplemented by a special task force. A departmental committee headed by an Inspector General of Police at the Secretariat oversees physical security at the sites. The CISF has developed the necessary ability to deploy specially-trained first responders in case of a nuclear emergency. However, the CISF is not in charge of all nuclear related installations in the country.

India has established a comprehensive material protection control and accounting program composed of three basic elements: (1) the legislative and regulatory framework; (2) an integrated physical protection program for facilities and materials; and (3) a comprehensive Nuclear Material Accounting and Control System. A Nuclear Control and Planning Wing was created in the Department of Atomic Energy (DAE) to take "the lead on international cooperation on nuclear security" by integrating DAE's safeguards, export controls, and nuclear security related activities.[1] However, given the nature of the threat environment, questions have been raised regarding physical protection at the sites where radiological sources, materials, devices, and instruments are used. Also, smuggling of radioactive materials in and around India is often reported.

Although security concerns are not overlooked in India, there is the absence of an overarching security apparatus looking after the nuclear installations. For instance, the physical security of nuclear installations is provided by multiple organizations such as the CISF, the local police, and sometimes even private security organizations. On the other hand, material accounting is handled by the DAE, and the review of security practices is the responsibility of the AERB. Thus, multiple organizations oversee the various aspects of nuclear security in the country, resulting in non-uniform nuclear security culture, norms, and SOPs.

This study has identified many areas where much more needs to be accomplished to improve the nuclear security culture and architecture in India. First, India should demonstrate more confidence and clarity in the essential elements of its nuclear security practices and make "transparency" a key feature of its nuclear security culture. There is a subtle attitudinal change that has taken root in India during the last few years: there is today a greater willingness by the

OBSERVATIONS

- During the seven decades of India's nuclear journey, no major nuclear disaster is known to have occurred except sporadic misconducts, industrial anomalies, and occasional negligence.
- The Mayapuri incident (2010) was a wake-up call for the establishment to tighten the controls as well as to reassure the public about the steps taken to do so.
- Subtle attitudinal change in India's nuclear establishment has taken root: there is today a greater willingness by the establishment to showcase its nuclear security arrangements before the public.
- Meanwhile, many institutional, legal, and operational reforms/changes have been undertaken to maintain international regime compliance.
- Although India has nurtured a comprehensive security arrangement, there exists ample scope for further improvement in all aspects relating to its nuclear security governance.

[1] "National Progress Report: India," *National Progress Reports*, 2014 Nuclear Security Summit, The Hague, Netherlands, March 24–25, 2014, p. 2. http://projects.iq.harvard.edu/files/nuclearmatters/files/national_progress_report_india.pdf

establishment itself to showcase its nuclear security arrangements before the public. Though India's regulatory body (AERB) is de facto independent, its complete autonomy from the promoting agency should be ensured through appropriate legislation. In pursuit of controlling the movement of radioactive materials it is suggested that all major Indian seaports should be equipped with technology aligned with the Container Security Initiative. Meanwhile, the international community must help mainstream India in the global nuclear order. It is in everyone's interest to facilitate India's entry into the export control organizations. India can be invited to observe such activities as nuclear security training, practices, and simulation exercises in other nuclear states and vice versa. India and the NSS should also consider convening regional nuclear security summits.

In addition to exploring India's approach to nuclear security, this study outlines a set of steps that may be undertaken within a specific timeframe to amplify India's nuclear security culture.

ACRONYMS AND DEFINITIONS

AEC	Atomic Energy Commission
AERB	Atomic Energy Regulatory Board
AHWR	Advanced Heavy Water Reactor
ATS	Anti-Terrorism Squad
BARC	Bhabha Atomic Research Centre
BHAVINI	Bharatiya Nabhikiya Vidyut Nigam Ltd.
CAG	Comptroller and Auditor General of India
CBRN	Chemical, Biological, Radiological and Nuclear
CII	Critical Information Infrastructure
CISAG	Computer Information and Security Advisory Group
CISF	Central Industrial Security Force
CPPNM	Convention on the Physical Protection of Nuclear Material
CRSA	Committee for Reviewing Security Aspects
DAE	Department of Atomic Energy
DBT	Design Basis Threat
DFGT	Directorate General of Foreign Trade
DRP	Directorate of Radiation Protection
ENR	Enrichment and Reprocessing
FBR	Fast Breeder Reactor
FTA	Foreign Trade (Development and Regulation) Act
GCNEP	Global Centre for Nuclear Energy Partnership
GICNT	Initiative to Combat Nuclear Terrorism
HEU	Highly Enriched Uranium
IAEA	International Atomic Energy Agency
ICSANT	International Convention for the Suppression of Acts of Nuclear Terrorism
IRRS	Integrated Regulatory Review Service
ITDB	International Trafficking Data Base
JNPT	Jawaharlal Nehru Port Trust
KNPP	Kudankulam Nuclear Power Plant
KRIBHCO	Krishak Bharati Cooperative Ltd.
LEU	Low Enriched Uranium
LWR	Light Water Reactor
MEA	Ministry of External Affairs
MTCR	Missile Technology Control Regime
MUs	Million Units (or Unit) is a gigawatt hour
MWBC	Mobile Whole Body Counter
NPCIL	Nuclear Power Corporation of India Ltd.
NPP	Nuclear Power Plant
NPT	Nuclear Non-proliferation Treaty

NSG	Nuclear Suppliers Group
NSRA	Nuclear Safety Regulatory Authority
NSS	Nuclear Security Summit
NTI	Nuclear Threat Initiative
NUMAC	Nuclear Material Accounting and Control
ONGC	Oil and Natural Gas Corporation
OSART	Operational Safety Review Team
PAC	Public Accounts Committee
PFBR	Prototype Fast Breeder Reactor
PHWR	Pressurized Heavy Water Reactor
PPS	Physical Protection System
PSU	Public Sector Undertaking
PWR	Pressurized Water Reactor
SAIL	Steel Authority of India Limited
SCOMET	Special Chemicals, Organisms, Materials, Equipment and Technology
SDV	Screen Distance Value
SIMS	Secondary Ion Mass Spectrometry
SNAS	Secure Network Access System
SNSS	School on Nuclear Security Studies
SOP	Standard Operating Procedure
UCIL	Uranium Corporation of India Ltd.
UGC	University Grant Commission
UK	United Kingdom
US	United States
WANO	World Association of Nuclear Operators
WMD	Weapons of Mass Destruction

1. INTRODUCTION

India is poised to enter a nuclear renaissance given the country's widespread belief that nuclear energy is a credible option for ensuring the availability of large amounts of energy in a relatively short time. This optimism about nuclear energy in India necessitates a debate on the security of the country's nuclear material and facilities. In addition to its ambitious plans for nuclear energy expansion, India faces other significant pressures to ensure stringent safe-keeping of its nuclear infrastructure. The deteriorating regional security environment, thriving terror and smuggling networks in the neighborhood, prevalent domestic dissident groups, and, above all, the unique nature of its nuclear program—including a series of negotiated exceptions—imply that nuclear security in India is more than a mere requirement for compliance with IAEA recommended guidelines: nuclear security for India is fundamental and indispensable, and it is clearly in India's best interests to be more forthcoming about the steps it has taken in this area. Given India's enthusiastic participation and official statements delivered during the various Nuclear Security Summits in 2010, 2012, 2014, and 2016 acknowledging the importance of nuclear security, one could say that India is conscious of the fact that credible threats to its nuclear infrastructure do exist. Because of its commitment to the NSS process and its own endeavor to secure its nuclear infrastructure, India, in coordination with international agencies and stakeholders, has undertaken several security measures to strengthen its nuclear security system. Since security threats are dynamic in nature, and the global nuclear security regime is still evolving, constant review of the threat and consequent national measures to meet the unfolding challenge are needed.

There is an emerging consciousness in India of the importance of nuclear security, which has been somewhat sharpened by public debate of the Mayapuri and Fukushima radiation incidents. In 2010, an unused gamma-irradiator from Delhi University was purchased by a scrap dealer. When workers later dismantled the device, cutting the cobalt-60 source into pieces, radiation was released and several individuals were exposed and sickened. One worker later died from the radiation exposure. Even though the incident did not lead to widespread radiation, it attracted a great deal of media attention in the country and exposed some of the loopholes in the country's nuclear safety-security system. The ensuing criticism was well-received by the establishment. Scientists working both inside and outside of the nuclear energy establishment offered in-depth analysis of the incident and recommendations.[2] The Mayapuri incident, along with the Fukushima Daiichi nuclear accident in 2011, served as a wake-up call for the Indian nuclear energy establishment to tighten the controls around nuclear facilities and materials as well as to reassure the public about the steps taken to do so.

This study offers a critical examination of India's nuclear security governance—both the strengths and weaknesses of the security system in place—considering several allegations advanced by a variety of institutions and actors operating both inside and outside of the country. In doing so, an attempt is made to describe the nature and status of India's current nuclear program, India's contemplation of the concept of nuclear security, and its integration with the global nuclear security regime. This study, relying purely on open sources, also scrutinizes the PPS in place in and around

[2] As an example, see Rajoo Kumar, "Lessons Learned from the Radiological Accident in Mayapuri, New Delhi, India," Atomic Energy Regulatory Board, Government of India, Mumbai, India. https://www.radiographers.org/downloads/Lessons-learned-from-Mayapuri-Accident.pdf

India's civilian nuclear installations. The major conclusion reached by this study is that although India has nurtured a comprehensive security arrangement, there exists ample scope for further improvement in all aspects relating to nuclear security governance in the county.

During the last seven decades of India's involvement with nuclear technology, no major nuclear disaster is known to have occurred, although they country has faced sporadic accusations of misconduct, industrial anomalies, and negligence. Indeed, India claims to have the distinction of over 478 "reactor years of safe, reliable and accident free operation" (up to 31 March 2018).[3] However, reported smuggling of radioactive materials, terrorists' interest in nuclear assets, and expanding usage of radiological materials in various industrial sectors make it important for India to address the weak links in its nuclear security governance to ensure that nuclear technology and material cannot fall into the wrong hands.

It is pertinent to inquire why India is ranked low in the nuclear security index created by the Washington D.C.-based Nuclear Threat Initiative (NTI), especially since India has a robust non-proliferation record and a long history of dealing with nuclear material. Because secrecy is considered a vital element of India's counterintelligence strategy, it is difficult for outsiders to obtain a clear picture of the security measures in place. Often, unavailability of information is mistaken for the absence of measures. Moreover, the historically interconnected nature of India's civil and strategic nuclear programs makes it more difficult to distinguish established safety and security measures. Finally, the tradition of secrecy seems to have manifested in a culture of 'insularity' and devotion to 'sticking with the program' as it is. With the 2008 Indo-US nuclear deal, followed by the NSG waiver, and the India-specific IAEA safeguards agreement, India has been able to widen its civil nuclear network involving various supplier countries and industrial houses. This has heralded both India's reengagement with the global nuclear order and a comprehensive rearrangement of its nuclear safety-security systems.

While hoping for NSG membership and massive expansion of its nuclear energy program, India must manage the dual challenge of maintaining its 'responsible state' status at the global level, while promoting greater acceptance of new

IMPERATIVES OF STRENGTHENING NUCLEAR SECURITY IN INDIA

- India has embarked on an ambitious nuclear energy expansion with plans to diversify its nuclear industry, involving both domestic and international private industrial houses. Diversification, though warranted, may pose additional safety-security challenges.
- India' nuclear infrastructure is fairly large and geographically dispersed.
- The use of radiological materials in various sectors is on the rise.
- India is located in a volatile region rife with terrorist activity.
- Clandestine nuclear proliferation networks are thriving in India's neighborhood.
- Smuggling networks are rampant in this region.

[3] S. K. Sharma, "Chairman's Statement," 31st Annual General Meeting 2018, Nuclear Power Corporation of India Limited, September 21, 2018, p. 3. https://www.npcil.nic.in/WriteReadData/userfiles/file/CMD_Statement_2018.pdf

nuclear energy projects at home. Therefore, this study, while mapping the contours of India's established nuclear security architecture, recommends that India develop confidence in its nuclear status to nurture transparency as a major factor in its nuclear security culture; nuclear information management through calibrated academic curricula; and graduated autonomy of the regulatory system, including adoption of international best practices across its nuclear programs.

Owing to the unavailability of information and the sensitivities involved in India's decisions related to nuclear weapons security, this study focuses mainly on India's civilian nuclear facilities and program. The study aims to highlight major aspects of the nuclear security architecture in India, which is largely understudied, and describe the scope for improvement in various domains related to nuclear security management.

Broadly, one can observe a subtle attitudinal change in India. There is a greater willingness to showcase its nuclear security arrangements before the public through such media as statements, press releases, annual reports, and national progress reports. Meanwhile, many institutional, legal, and operational reforms have been undertaken to maintain international regime compliance. Prior to the NSS process, nuclear security and safety were rarely discussed by the establishment. Today, both the government and the nuclear establishment are eager and enthusiastic to engage with various stakeholders while proactively tackling legal, institutional, and technological reforms.

The challenge, however, is to keep the various states in the international community, including India, interested in discussing and sharing best practices in the field of unclear security given that the NSS process has now come to an end.

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2. INDIA AND THE GLOBAL NUCLEAR ORDER

India's position in the international nuclear order has evolved over time. At the dawn of the nuclear age, India frequently engaged in anti-nuclear activism, proposing an end to nuclear testing in 1954 after the United States (US) conducted nuclear testing in the Bikini Atoll[4], and signing the Partial Nuclear Test Ban Treaty in 1963. India played a major role in the discussions to establish the IAEA and actively participated in the negotiations on the NPT but decided not to sign the agreement when it became clear that it would become an unequal treaty. As Scott Sagan points out, "In the actual negotiations creating the NPT text, Sweden and India proposed to include a commitment to a number of 'tangible steps,' including security assurances for non-nuclear-weapons states, an end to nuclear testing, and a freeze on the production of nuclear weapons in the treaty. The US and the Soviet Union refused to allow such specific measures to be included in the final text of the NPT."[5] India, although not a party to the NPT, voluntarily made subject six of its nuclear reactors to IAEA inspections even though it was under no obligation to do so. The Indian nuclear tests of 1974 prompted several NPT countries to establish the NSG to govern the supply of nuclear materials and technology.

Because of the 1974 nuclear tests, a nuclear embargo was imposed on India whereby India was denied such nuclear technology and material as nuclear fuel and uranium. This prevented Indian scientists from gaining adequate exposure to international nuclear research and institutions, and, unfortunately, early indoctrination into a culture of safety and security. In a sense, this also led to an unhealthy tradition of secrecy regarding nuclear matters in India, as the Indian nuclear establishment had to shield developments in the country's nuclear program from external actors.

2.1. India's Integration with the Global Nuclear Order

Despite its past, India is well on its way to becoming an integral part of the international nuclear order, both in its strategic and civilian nuclear programs. Sustained nuclear dialogue with the US began in 2005, when President Bush and Indian Prime Minister Manmohan Singh initiated nuclear cooperation. This engagement led to a new Indo-US partnership, which, in turn, redefined Indian engagement with the international nuclear order. After years of sustained negotiations, India and the US announced an Indo-US nuclear deal in 2005. The agreement was signed in October 2008, virtually ending India's isolation in the global nuclear order. The bargain struck by the two countries was a useful compromise: New Delhi did not have to give up its nuclear weapons to be part of the international nuclear order, and the NPT did not have to be rewritten to accommodate India.

In 2008, after considerable negotiations, the NSG—which normally prohibits its members from nuclear commerce with states that have not signed the NPT—agreed on a special waiver for India.[6] Despite the NSG waiver, there is a certain lack of clarity about whether India will be able to benefit from enrichment and reprocessing (ENR) technology transfer, for which the NSG is now framing new rules. In amending its guidelines in 2011, the NSG stressed it would restrict ENR commerce to

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[4] Indian Prime Minister Jawaharlal Nehru asked the two superpowers to reach a 'Standstill Agreement' on nuclear weapon testing. Text of Nehru's demand is available at http://www.pugwashindia.org/Issue_Brief_Details.aspx?Nid=73

[5] Scott D. Sagan, "Convenient Consensus and Serious Debate about Disarmament." Discussion paper presented to the Working Group on an Expanded Non-Proliferation System, Washington, D.C., June 8–9, 2010. http://www.nti.org/media/pdfs/ConvenientConcensusDebateDisarmament-ScottSagan-060610_2.pdf?_=1326132026

[6] Wade Boese, "NSG, Congress Approve Nuclear Trade with India," *Arms Control Today*, October 2008. https://www.armscontrol.org/act/2008_10/NSGapprove

parties to the NPT. However, the US, France, and Russia have said that they will continue to operate under the 2008 NSG exemption for India, meaning future NSG guidelines would not adversely affect their ENR trade with India.[7]

India has played an active role in the IAEA since its inception and has continued to emphasize the importance of the IAEA's role in promoting peaceful uses of nuclear science and technology. India is also a strong proponent of the safety, security, and safeguards related responsibilities outlined by the IAEA. India participates in the IAEA's advisory groups and technical committees and contributes to its activities by providing experts, organizing training programs and workshops, and providing equipment. India is one of the founding members of the IAEA's International Project on Innovative Reactors and Fuel Cycles, contributing $50,000 annually towards the program.[8]

On February 2, 2009, India and the IAEA signed the *Agreement Between the Government of India and the International Atomic Energy Agency for the Application of Safeguards to Civilian Nuclear Facilities* that entered into force on May 11, 2009. As part of the agreement, India has placed 14 out of 22 civilian reactors under the IAEA inspection regime.[9] India is implementing a separation plan for civilian and military reactors/facilities so that there is no cross-feeding of nuclear material from one to the other. As of September 2018, India has placed 26 nuclear facilities under the IAEA safeguards.[10]

2.2. India and the International Export Control Regime

Other than the major treaty commitment of the NPT, one of the major features of the contemporary nuclear order is the existence of international nuclear and related cartels. These export control organizations have traditionally sought to isolate India. However, post-2008, New Delhi was in constant negotiations to gain membership to various international export control regimes: the NSG;'[11] the Missile Technology Control Regime (MTCR);'[12] the Australia Group;'[13] and the Wassenaar Arrangement.[14] Of the four, the NSG, which deals directly with nuclear issues, is the most significant in regard to the civilian reactors in India. While New Delhi formerly viewed these informal arrangements as technology-denial regimes, today it feels the need to engage them in a mutually beneficial manner. India has become a member of the Missile Technology Control Regime, the Wassenaar Arrangement, and now the Australia Group, three of the four non-proliferation regimes.

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[7] Siddharth Varadarajan, "Challenges Ahead for India's Nuclear Diplomacy," *The Hindu*, November 1, 2011. http://www.thehindu.com/todays-paper/tp-opinion/challenges-ahead-for-indias-nuclear-diplomacy/article2586970.ece

[8] Government of India, "India and the IAEA," Indian Embassy (Vienna). http://www.indianembassy.at/pages.php?id=64

[9] "India Notifies Separation Plan to IAEA," *Economic Times*, October 16, 2009. http://articles.economictimes.indiatimes.com/2009-10-16/news/27657210_1_separation-plan-iaea-board-safeguards-agreements

[10] "India Puts Four More Nuclear Facilities under IAEA Safeguards," *The Hindu Business Line*, September 19, 2018. https://www.thehindubusinessline.com/economy/india-puts-four-more-nuclear-facilities-under-iaea-safeguards/article24988409.ece

[11] For more on NGS, see http://www.nuclearsuppliersgroup.org/Leng/02-guide.htm

[12] For more on MTCR, see http://www.mtcr.info/english/

[13] For more on the Australia Group, see http://www.australiagroup.net/en/index.html

[14] For more on the Wassenaar Arrangement, see http://www.wassenaar.org/introduction/index.html

India's desire to join the NSG has fallen prey to the vicissitudes of geopolitics even though it was accorded a waiver to engage in nuclear trade as far back as 2008. While India's candidature for the NSG has been supported by the major powers including the US, United Kingdom, and France, India's entry has been vetoed by China, a member of the NSG and the UNSC. .

Apart from the vagaries of geopolitical calculations, non-adherence to the NPT remains the most serious stumbling block to India's acceptance in the NSG. However, given that the Wassenaar Arrangement waived the NPT requirement while admitting India into its fold, and that the NSG is a private cartel, the members can easily decide to waive the NPT requirement. India fulfills every other criterion for an NSG membership.

Over the years, India also revised its domestic export control regime to align with the control lists stipulated by the various international export control organizations. Rajiv Nayan writes: "The Special Chemicals, Organisms, Materials, Equipment and Technology (SCOMET) list is the principal regulatory mechanism for Indian export controls. It is regularly updated and expanded frequently, depending on the pace of technology…. The Indian export control system was revamped in keeping with the guidelines and technology control lists of the NSG and the MTCR as per the July 18, 2005 joint statement."[15]

India has been an enthusiastic participant in the NSS process since 2010. It supported the Washington Summit Communiqué and Work Plan of the first NSS in 2010 and announced that it would establish a Global Centre for Nuclear Energy Partnership, which has since been formed. India hosted an NSS 'Sherpa' preparatory meeting in New Delhi on January16-17, 2012. At the second NSS in 2012, India pledged $1 million towards the IAEA's Nuclear Security Fund for 2012–13. Many view that "the summits failed to convince New Delhi to increase transparency" and "have proved unable to break through India's penchant for secrecy on what it considers to be matters of national security…."[16] India was highly engaged at the NSS summits of 2014 and 2016.[17] [18] In the plenary statement at the 2014 summit, the leader of India's delegation, External Affairs Minister Shri Salman Khurshid, underlined that "India had not wavered in its commitment to global efforts to prevent the

INDIA'S CHANGING ROLE IN THE GLOBAL NUCLEAR ORDER

- India played a major role in discussions to establish the International Atomic Energy Agency and the Nuclear Non-proliferation Treaty.
- Following India's 1974 nuclear weapons test, India was denied access to nuclear technology and material, leading to an unhealthy culture of secrecy in its nuclear program.
- Since 2005, India has engaged in sustained dialogue with the global nuclear order.
- India is working to engage with the international export control regime. India is a member of three of the four non-proliferation regimes: the Missile Technology Control Regime, the Wassenaar Arrangement, and the Australia Group.

[15] Rajiv Nayan, "Integrating India with the Global Export Controls System: Challenges Ahead", *Strategic Analysis*, 35:3, p. 441.
[16] P. R. Chari, "India's Role in the Hague Nuclear Security Summit," *Proliferation Analysis*, Carnegie Endowment, March 18, 2014. http://carnegieendowment.org/2014/03/18/india-s-role-in-hague-nuclear-security-summit/h4iw
[17] "National Progress Report: India." *National Progress Reports*, 2014 Nuclear Security Summit, The Hague, Netherlands, March 24–25, 2014. http://projects.iq.harvard.edu/files/nuclearmatters/files/national_progress_report_india.pdf
[18] Rajeswari Pillai Rajagopalan, "India and the Nuclear Security Summit," April 27, 2016. https://www.orfonline.org/research/india-and-the-nuclear-security-summit/

proliferation of weapons of mass destruction and their means of delivery."[19] India has also declared its intention to establish an independent Nuclear Safety Regulatory Authority (NSRA) to enhance oversight of nuclear security and strengthen synergy between safety and security.[20] The legislation to establish the authority was tabled in the Indian parliament, but the bill has since lapsed, as the last session of the 15th Lok Sabha could not pass the bill before the general elections in April 2014.[21] The new government is likely to reintroduce the bill in the parliament soon.

At the 2016 NSS summit, India's participation exhibited the country's new-found confidence about its own record of nuclear security and a positive outlook on global nuclear security intuitions and regimes. At the summit, India stated: "India agreed to join 'gift baskets' in the areas of counter-nuclear smuggling, sharing know-how and best practices through centers of excellence such as India's GCNEP, and moving the summit process forward through an informal Contact Group in Vienna."[22]

[19] Statement by Bhaswati Mukherjee, "3rd Nuclear Security Summit, The Hague, Netherlands (March 24–25, 2014)," Available on the Government of India's website, dated April 9, 2014, at http://mea.gov.in/in-focus-article.htm?23194/3rd+Nuclear+Security+Summit+The+Hague+Netherlands+2425+March+2014

[20] "India," *Nuclear Security Summit National Progress Report*, 2012 Nuclear Security Summit, Seoul, South Korea, March 27, 2012. http://www.mea.gov.in/bilateral-documents.htm?dtl/19074/. For more details on India's participation at the 2012 NSS meeting, see http://www.mea.gov.in/global-issue-detail.htm?85/Nuclear+Security+Summit+2012

[21] Nuclear Safety Regulatory Authority Bill, 2011. http://www.prsindia.org/uploads/media/Nuclear%20Safety/Nuclear%20Safety%20Regulatory%20Authority%20Bill%202011.pdf

[22] Rajeswari Pillai Rajagopalan, "India and the Nuclear Security Summit," April 27, 2016. https://www.orfonline.org/research/india-and-the-nuclear-security-summit/

3. STATE OF INDIA'S NUCLEAR PROGRAM

In 2006, the government of India released a report titled the "Integrated Energy Policy of India" that considers the role of nuclear power as "the most potent means to long-term energy security," and, therefore, prescribes "accelerated development of nuclear source for sustainable development of the country."[23] In the decade and a half since the release of that report, India has experienced sustained interest and growth in its nuclear sector and has initiated civil nuclear cooperation with around two dozen countries and three dozen industrial houses. Hallmarks of this effort include the civil nuclear agreement with the US, the India-specific safeguards agreement with IAEA, and the NSG waiver in 2008[24]

Currently, nuclear energy supplies approximately 3% (3.2% during 2016–17 and 2.93% during 2017–18) of the total electricity produced in the country[25]. That figure is expected to grow in the coming years. According to the World Nuclear Association's website, India's vision is "to have 14,600 MWe nuclear capacity on line by 2020;" and, in the long-term, "to supply 25% of electricity from nuclear power by 2050."[26] The government responded to a recent question on India's target for atomic energy production in the next 20 years in this way:

> [T]he Government has planned to increase the installed capacity base of nuclear power in the country for increased electricity production from nuclear power. The present installed nuclear power capacity of 6780 MW would reach 13,480 MW by the year 2024–25 with the completion of projects under construction . . . . The Government has also accorded administrative approval and financial sanction for 12 nuclear power reactors aggregating a total capacity of 9000 MW, which are scheduled to be completed progressively by the year 2031. On their completion, the total nuclear power capacity would reach 22,480 MW.[27]

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[23] Government of India, Planning Commission, *Integrated Energy Policy: Report of the Expert Committee*, 2006, p. xxii.

[24] Sitakanta Mishra, "India's Civil Nuclear Network," *Air Power Journal*, Vol. 5, No. 4, (October–December 2010), pp. 107-32.

[25] Parliament of India, Lok Sabha, Unstarred Question No. 1668, "Atomic Energy Based Power," Answered on February 13, 2019; and Rajya Sabha, Unstarred Question 1597, "Plans to Increase Generation of Atomic Energy," Answered on March 16, 2017.

[26] World Nuclear Association, "Nuclear Power in India," Country Profile, September 2014 (updated February 2019). http://world-nuclear.org/info/Country-Profiles/Countries-G-N/India/

[27] Parliament of India, Lok Sabha, "Atomic Energy Production," Unstarred Question No. 361, Answered on December 12, 2018.

In an eight-year span, nuclear power output in India increased by over 80%, from 18,634 million units (MUs)[28] in 2006–07 to 35,333 MUs during 2013–14).[29] Uranium supplies from Canada, France, Kazakhstan, and Russia have helped Indian reactors to operate with high capacity. The capacity factor rose to 79% in 2011–12 from 71% the previous year. Subsequently, as per the IAEA, "overall capacity factor of operating reactors of NPCIL was 82% during 2014-15." Especially the PHWRs reach peak capacity of 10,060 MW by 2017 and operated at 85% capacity factor."[30]

In a quest to leverage its nuclear industry, India is pursuing development of nuclear power plants using a mix of indigenous PHWRs, FBRs, and LWRs based on foreign technical cooperation and fueled by imported enriched uranium. These plants operate under IAEA safeguards. Presently, 18 PHWRs, with a total capacity of approximately 4460 MWe, are in operation.[31] In June 2017, the government accorded administrative approval and financial sanction for ten indigenous PHWRs of 700 MW each in fleet mode.[32] Today, PHWRs comprise over 80% of India's installed nuclear reactors and are claimed to have some safety and operational advantages over the PWRs, including ". . . not requiring refueling outages, as well as greater fuel cycle flexibility. . . . [They also] can more easily utilize lower enriched uranium, reprocessed fuel, and potentially thorium."[33] India's PHWR technology and expertise seems to be maturing. The Kaiga unit 1 has set a world record for continuous operation of unbroken 941 days.[34] Beyond 2030, India plans a large expansion based on FBRs, and later thorium-based reactors, as part of its closed fuel cycle approach. India's three-stage nuclear power program—which will be discussed in more detail in section 3.1 below—strives to extract the maximum energy from the limited uranium

STATE OF INDIA'S NUCLEAR PROGRAM

- Nuclear energy supplies approximately 3% of India's total electricity.
- India hopes to supply 25% of its electricity from nuclear power by 2050.
- India currently has an installed nuclear capacity of 6780 MW.
- PHWRs comprise of 80% of India's installed nuclear reactors.
- India imports nearly half of its uranium requirements but has stepped up domestic mining projects in recent years.
- To realize its ambitious goals, India has established an integral and coordinated framework involving specialized agencies, academic institutions, public sector undertakings, and private industrial houses.

[28] 1 MU = 1 Gigawatt-hour
[29] Nuclear Power Corporation of India Ltd., "Nuclear Power Generation (2006-07 to 2014-15)." http://www.npcil.nic.in/main/allprojectoperationdisplay.aspx
[30] Anshu Bharadwaj et al., "Nuclear Power in India: The Road Ahead", http://www.cstep.in/drupal/sites/default/files/2019-07/CSTEP_RR_Nuclear%20power%20in%20India_2008.pdf, p. 60.
[31] Nuclear Power Corporation of India Ltd., "Plants Under Operation." https://www.npcil.nic.in/content/302_1_AllPlants.aspx
[32] Government of India, Department of Atomic Energy, "Setting up of Ten Indigenous Nuclear Power Reactors," Press statement released July 19, 2018. https://pib.gov.in/newsite/PrintRelease.aspx?relid=180734
[33] Bill Linton, "Market Overview: The Outlook for Nuclear Power in India," *Power Engineering*, Issue 2, Vol. 7, April 16, 2014. https://www.power-eng.com/2014/04/16/market-overview-the-outlook-for-nuclear-power-in-india/
[34] "Indian Reactor Sets New World Record," *World Nuclear News*, December 11, 2018. http://www.world-nuclear-news.org/Articles/Indian-reactor-sets-new-world-record

resources, provide (arguably) "inherent proliferation resistance,"[35] and ensure long-term energy security.[36]

To expedite its ambitious nuclear industry, India imports about 40% of its uranium requirements.[37] However, a stated goal of the Indian government is to ensure energy security by "building strategic stockpile of nuclear fuel to counter the risk of disruption of international fuel supply".[38] To illustrate the importance of this goal, India failed to reach its 11th Five Year Plan (2007–2012) goal of energy production because it was unable to access enough uranium.[39] While reaching out to potential uranium suppliers across the globe, India also plans for optimal utilization of the country's scarce uranium resources. In five states, 13 uranium mining projects are currently in different stages of exploration.[40] The two processing plants at Jaduguda and Turamdih prepare yellow cake and send it to the Nuclear Fuel Complex at Hyderabad for further processing into uranium oxide pellets. The plant at Jaduguda has the capacity to process 2500 tonnes (one tonne is equal to a metric ton, or 1,000 kg) of ore per day.[41] India continues to make progress in finding new uranium resources in the country through extensive exploration work, using multiple technologies. In 2012, with the use of advanced techniques, India was able to identify new sources of uranium, and reserves have registered an increase of about five percent.[42] During 2012–13, the "performance of all operating units of [the Uranium Corporation of India Limited (UCIL)] has been quite satisfactory, recording highest ever mineral production as well as ore processed and dispatch to Nuclear Fuel Complex."[43] The UCIL's Control Research and Development Department, which monitors the recovery process of uranium and its byproducts,[44] stated in its 2016–17 annual report that the "performance of all operating units has been satisfactory."[45]

To achieve the targeted and judicious mobilization of expertise and resources, India has put in place an integral and coordinated framework involving specialized agencies, academic institutions, public sector undertakings (PSUs), and private industrial houses. By mobilizing both domestic and international stakeholders, India plans to strengthen its technological and human resource base and acquire more uranium and technology. India aspires to participate in international nuclear commerce as a supplier by becoming a member of NSG. As a long-term strategy, India has plans to diversify its nuclear industry, involving such domestic and international private industrial houses as Larson & Toubro, Tata, Relience, Punj Lloyd, Westinghouse, Areva, GE, and Sandpit. To reduce the burden

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35 Bhabha Atomic Research Centre, *Indian Programme on Reprocessing*. http://www.barc.gov.in/publications/eb/golden/nfc/toc/Chapter%206/6.pdf.

36 Ibid.

37 "World Nuclear Association, "Nuclear Power in India," July 30, 2014. http://www.world-nuclear.org/info/Country-Profiles/Countries-G-N/India/

38 Government of India, Press Information Bureau, "Integrated Energy Policy" Press statement released December 26, 2008. http://www.pib.nic.in/newsite/erelease.aspx?relid=46172

39 "Uranium Shortage Hit Nuclear Power Generation Target in 11th Plan," *Firstpost*, July 23, 2014. http://www.firstpost.com/india/uranium-shortage-hit-nuclear-power-generation-target-11th-plan-1631071.html

40 Uranium Corporation of India Ltd., "Uranium Occurrence and Production Centres in India." http://www.ucil.gov.in/opr.html

41 Ramendra Gupta, "Nuclear Energy Scenario of India," Uranium Corporation of India Limited, p. 7.

42 Statement by Ratan Kumar Sinha, Chairman of the Atomic Energy Commission and Leader of the Indian Delegation, to the 57th General Conference, Vienna, September 18, 2013., p. 4.

43 Uranium Corporation of India Ltd., *46th Annual Report 2012–2013*, p. 9. http://www.ucil.gov.in/web/Annual%20Report%20-%20English%20-2012-13.pdf

44 Uranium Corporation of India Ltd., "Control Research and Development." www.ucil.gov.in/web/control_research_&_development.html

45 Uranium Corporation of India Ltd., *50th Annual Report 2016–2017*, p. 8. http://www.ucil.gov.in/pdf/report/anual_report_16-17.zip

on the two PSUs in charge of nuclear-related activities—Nuclear Power Corporation of India Ltd. (NPCIL) and BHAVINI—India is planning to diversify the operational and management responsibilities of nuclear plants among other PSUs. In 2015, the amendment to the Atomic Energy Act of 1962 has paved the way for Atomic Energy Units, including NPCIL, to enter into joint ventures with other PSUs and government sector companies.[46] The National Aluminum Corporation, Indian Oil Corporation, Indian Railways, Oil and Natural Gas Corporation (ONGC), Steel Authority of India Limited (SAIL), and NTPC are potential candidates for such collaborations.[47] As revealed during the Lok Sabha Debate, NPCIL has entered into a joint venture with NTPC and the Indian Oil Corporation Ltd. "The [joint venture] companies, Anushakti Vidhyut Nigam Ltd. and NPCIL-Indian Oil Nuclear Energy Corporation Ltd. respectively have been incorporated. An exploratory discussion was also held with ONGC in this regard."[48] Although the Indian Railways is not contemplating entering into a memorandum of understanding to establish a nuclear power plant,[49] if things go right, more players will be seen in India's nuclear energy sector soon. Though warranted, diversification of India's nuclear security program may pose additional safety and security challenges for India in the years ahead.

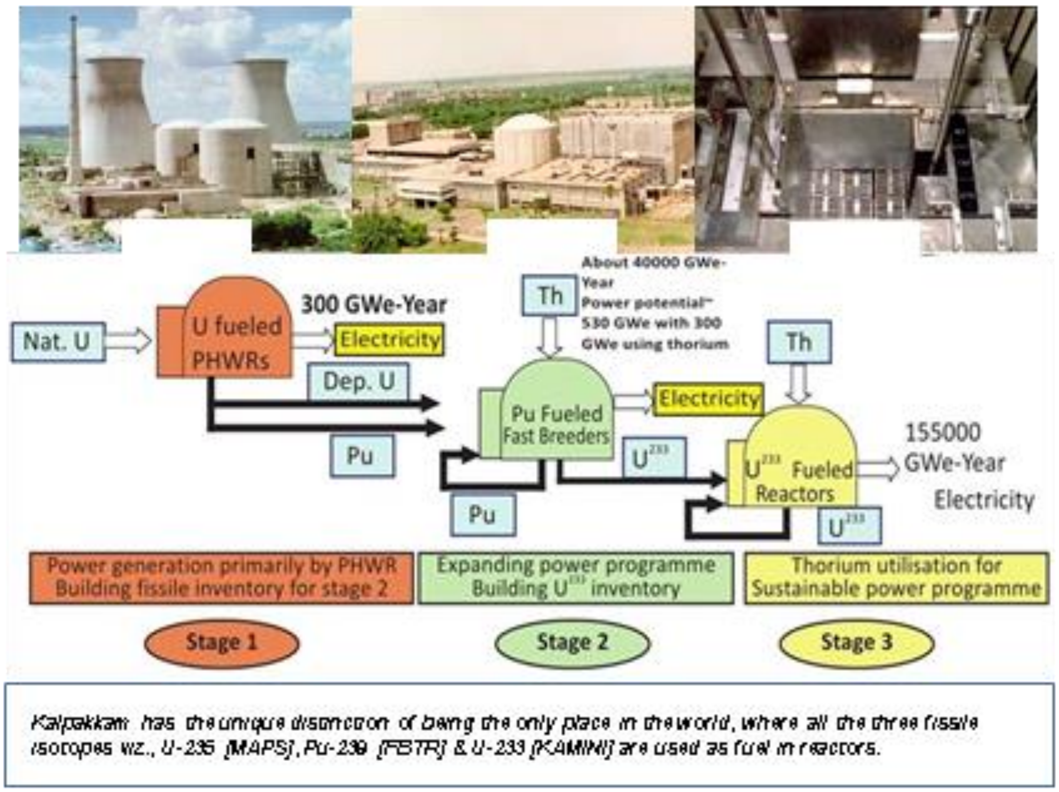
3.1. The Three-Stage Program

It can be argued that long before the issue of nuclear security drew the attention of the global community, India has attempted to pursue a unique technological path called the three-stage program, which aims to maximize the security of nuclear materials and achieve nuclear resource extension and sustainability.

According to India's nuclear establishment, the three-stage Indian nuclear power program is devised to utilize available resources efficiently and in a sustainable manner. Fundamentally, India's 'reprocess to reuse' nuclear strategy avoids both the buildup of stockpiles as well as the need to store large amounts of spent fuel that could be misused by bad actors in the region. The first stage, which mainly comprises the PHWRs, uses domestic natural uranium as fuel to generate electricity. In this stage, natural uranium (U-235, 0.72%) undergoes fission, and a portion of the remaining U-238 is converted to Pu-239. The spent fuel generated from this stage is reprocessed to recover the Pu-239 to be utilized as fuel in the FBRs in the second stage.[50] Besides using Pu-239 as fuel, FBRs also make use of thorium as blanket in the reactor core. The thorium (Th-232) undergoes nuclear mutation in the reactor core to produce U-233. Therefore, the second stage constitutes the FBRs along with reprocessing plants and plutonium-based fuel fabrication plants. The U-233 produced in the second stage, along with thorium, is used as fuel in the third stage of reactors. According to Dr. S. K. Jain, former chairman and managing director of India's Nuclear Power Corporation, this strategy allows India "to make optimum use of our vast thorium reserves for sustained power generation to cater to

[46] Government of India, Department of Atomic Energy, "Lok Sabha Passes 'Atomic Energy Bill 2015,'" Press statement released December 14, 2015. http://pib.nic.in/newsite/PrintRelease.aspx?relid=133214
[47] World Nuclear Association, "Nuclear Power in India," July 30, 2014. http://www.world-nuclear.org/info/Country-Profiles/Countries-G-N/India/
[48] Government of India, Department of Atomic Energy, "Joint Venture by NPCIL for Production of Electricity," Press statement released December 15, 2016. https://pib.gov.in/newsite/PrintRelease.aspx?relid=155442
[49] Parliament of India, Lok Sabha, "Nuclear Power Generation," Unstarred Question No. 638, Answered on February 6, 2019.
[50] Ramendra Gupta, "Nuclear Energy Scenario of India," https://www.scribd.com/document/103000446/Nuclear-Energy-of-India

the long-term needs of the nation."[51] Currently, India is entering into the second stage of the three-stage program and has established three reprocessing plants to extract plutonium.[52]



Source: http://www.barc.gov.in/reactor/tfc_3sinpp.html

Figure 1. India's Three-Stage Nuclear Power Program

3.2. Use of Radiological Material

Besides energy production, India is pursuing comprehensive programs in radiation and isotope technologies for societal benefit in such areas as food preservation, development of superior mutant varieties of seed/crops, nuclear medicine for diagnostics and radiation therapy, industrial radiography, and sewage and waste management. These areas have registered phenomenal growth in recent years. In the medical sector alone, more than 57,443 medical X-ray units are in operation in various parts of the country.[53] According to a 2019 study, "currently India has approximately 545 teletherapy machines (180 telecobalt units and 365 medical accelerators), 22 advanced therapy machines (7 Gamma knife units, 8 Tomotherapy machines, 7 Cyber-knife machines and 2 intra-

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[51] Interview with Dr. S. K. Jain, Chairman and Managing Director of the Nuclear Power Corporation of India from 2004 to 2012 in IEEMA Journal, February 6, 2012, p. 48. http://npcil.nic.in/pdf/ten_06feb2012_01.pdf

[52] Ramendra Gupta, "Nuclear Energy Scenario of India," Uranium Corporation of India Limited. http://www.ucil.gov.in/web/nu_energy_of_india.pdf

[53] Government of India, Comptroller and Auditor General of India, *Report No. 9 of 2012 - Performance Audit on Activities of Atomic Energy Regulatory Board Union Government, Atomic Energy*. 2012. https://cag.gov.in/content/report-no-9-2012-performance-audit-activities-atomic-energy-regulatory-board-union

operative radiotherapy machines). The number of remote after loading brachytherapy units is estimated at around 250." (see **Error! Reference source not found.**&2).[54]

Table 1
Distribution of Radiotherapy Machines across Geographical Regions

Region	Population of each region (%)	Area of each region (%)	Number of machines available in each region (%)							
			Simulator	CT-Sim	Telecobalt	Linacs	RAL Brachy	Tomo	Cyber Knife	Gamma Knife
Central	8.10	13.6	1 (2.5)	2 (4)	15 (8.3)	12 (3.3)	13 (5.2)	0 (0)	0 (0)	0 (0)
East	22.33	12.8	4 (10)	1 (2)	20 (11.1)	22 (6)	16 (6.4)	1 (12.5)	0 (0)	0 (0)
North	24.82	20.5	15 (37.5)	13 (26)	42 (23.3)	85 (23.3)	65 (26)	1 (12.5)	3 (42.9)	5 (71.4)
North-East	3.57	7.8	1 (2.5)	3 (6)	10 (5.6)	6 (1.6)	6 (2.4)	0 (0)	0 (0)	0 (0)
South	21.09	19.4	12 (30)	18 (36)	50 (27.8)	150 (41.1)	88 (35.2)	3 (37.5)	4 (57.1)	1 (14.3)
West	20.09	26.0	7 (17.5)	13 (26)	43 (23.9)	90 (24.7)	62 (24.8)	3 (37.5)	0 (0)	1 (14.3)
Total	100	100	40 (100)	50 (100)	180 (100)	365 (100)	250 (100)	8 (100)	7 (100)	7 (100)

States included in each region: Central: Chhattisgarh, Madhya Pradesh, East: Bihar, Jharkhand, Orissa, West Bengal, North: Chandigarh, Delhi, Haryana, Himachal Pradesh, Jammu and Kashmir, Punjab, Uttar Pradesh, Uttarakhand, North-East: Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura, South: Andhra Pradesh, Karnataka, Kerala, Puduchery, Tamilnadu, Telengana, West: Goa, Gujarat, Maharashtra, Rajasthan, States not included: Andaman & Nicobar Islands, Sikkim, D & N Haveli, Daman & Diu, Lakshadweep; CT: Computed tomography, RAL: Remote after-loading

Source: http://www.indianjcancer.com/viewimage.asp?img=IndianJournalofCancer_2019_56_4_359_268964_t1.jpg

Table 2
Brachytherapy Facilities

Brachytherapy	No. of units
HDR units	250
LDR Units	06
Intraoperative Radiotherapy (IORT) Unit	02
Facilities using Cs-137 manual Intracavitary Brachytherapy Sources	61
Facilities using Ir-192 manual Interstitial Brachytherapy Source	20
Facilities using Sr-90, Ru-106, I-125 Ophthalmic sources	47
Facilities using I-125 Prostate Implant seed sources	02

HDR=High dose rate; LDR=Low dose rate

Source: http://www.indianjcancer.com/viewimage.asp?img=IndianJournalofCancer_2019_56_4_359_268964_t2.jpg

Since 1960, India has been a leader in the production, use, and supply of radioisotopes in large volume for agriculture, cancer treatment, medical diagnosis, sterilization of medical products, quality control, non-destructive testing and processing of polymeric materials. According to a study reported on in 1999, starting around the late 1990s "over 10 kilocuries of various products are handled every month and about 4000 consignments are supplied to 1900 users and institutions in India and abroad."[55] Within India, in 2009, just over 150 hospitals had nuclear medicine

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54 Anusheel Munshi et al., "Radiotherapy in India: History, current scenario and proposed solutions", *Indian Journal of CANCER*, Vol. 56, Issue 4, 2019, http://www.indianjcancer.com/article.asp?issn=0019-509X;year=2019;volume=56;issue=4;spage=359;epage=363;aulast=Munshi
http://www.aerb.gov.in/AERBPortal/pages/English/t/publications/SJBook.pdf

55 M. Ananthakrishnan, et al., "Large Scale Production of Radioisotopes from Research Reactors for Medical and Industrial Applications – The Indian Experience," Research Reactor Utilization, Safety and Management, Symposium

departments. By 2018, the number had increased to 293.[56] The DAE, along with the Board of Radiation and Isotope Technology, has plans to gradually increase the production and supply of radioisotopes, especially those used in nuclear medicine in the country.[57] Currently, in India there are many commissioned 22 gamma irradiator plants (7 more are under construction) out of which 17 are in the private sector.[58]

Widespread use of such materials and technology poses a serious challenge in terms of managing their safety and security. One recent incident clearly illustrates the need for continued emphasis on strong radiological safety and security practices. On June 25, 2019, a radiography agency of Navi Mumbai was transporting an industrial radiography exposure device model Delta-880 containing approximately 1.53 TBq (41.4 Ci) Ir-192 source. The car carrying the source was involved in a collision that resulted in the loss of the source. The radiography agency's radiological safety officer reached the accident site but could not locate the radiography device. After three days, the source was recovered from a scrap dealer located approximately 10 km from the accident site. As there was no damage to the device, the incident did not raise any radiological safety concerns.[59] The event is rated as level 1 on the International Nuclear Even Scale and is viewed by the IAEA as a "degradation of Defence In-Depth".[60]

Many radioactive consignments (nearly 100,000 per year) are transported within the country, and many more transit across its borders. Given the surging economic development and demand in various sectors of economy, application of radiological material in the country is bound to increase. As the use of radiological materials increases in every sector in India, the safety and security of such sources will continue to challenge the country in the years to come.

3.3. The Strategic Program

According to the government of India's draft nuclear doctrine, India has a strategic nuclear program based on the doctrinal posture of 'no-first-use' and retaliatory capability with "massive retaliation…to inflict damage unacceptable to the aggressor."[61] India is also preparing its third leg of the nuclear triad: The INS Arihant, a 6000-ton submarine with an 83 MW pressurized light-water reactor on board, is on extensive sea-trials.

Although no exact number on India's nuclear weapons inventory is available, it is speculated that New Delhi possesses enough weapon-usable plutonium to build between 100 and 130 nuclear

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Proceedings, IAEA-SM-360/1P, September 1999, p. 1. https://www-pub.iaea.org/MTCD/publications/PDF/csp_004c/PDFfiles/001P.pdf

[56] "India to Boost Radioisotopes Production to Meet Rising Demand for Nuclear Medicine," *Nuclear Asia*, February 25, 2019. http://www.nuclearasia.com/news/india-boost-radioisotopes-production-meet-rising-demand-nuclear-medicine/2859/

[57] "DAE Plans to Increase Production of Radioisotopes for Nuclear Medicine," *The Indian Express*, February 24, 2019. https://indianexpress.com/article/cities/mumbai/dae-plans-to-increase-production-of-radioisotopes-for-nuclear-medicine-5598403/

[58] BRIT, Govt. of India, "Rad. Proc. Plants in Private Sector", http://www.britatom.gov.in/htmldocs/rpp_pvt.html

[59] Government of India, Atomic Energy Regulatory Board, "Information on Recovery of Industrial Radiography Source," June 28, 2019. https://www.aerb.gov.in/storage/uploads/News/newsWivHH.pdf

[60] International Atomic Energy Agency, "Loss and Subsequent Recovery of a Radiography Device Containing Source," July 8, 2019. https://www-news.iaea.org/ErfView.aspx?mId=0c07439a-2b52-4ff7-a204-f98273f8357a

[61] Government of India, Ministry of External Affairs, "Draft Report of National Security Advisory Board on Indian Nuclear Doctrine," August 17, 1999. https://mea.gov.in/in-focus-article.htm?18916/Draft+Report+of+National+Security+Advisory+Board+on+Indian+Nuclear+Doctrine

bombs, and these numbers are expected to grow in the coming years.[62] No public information is available on the holding of unirradiated civilian plutonium, but India is believed to have several tons of unirradiated reactor grade material, i.e., weapon-usable plutonium, that it plans to use in its breeder reactor program. According a February 2018 report from the International Panel on Fissile Materials:

> "India's stockpile of fissile materials is estimated to include 4.0±1.4 tonnes of HEU enriched to about 30% uranium-235, 0.58±0.15 tonnes of weapon-grade plutonium, and 6.4±3.5 tonnes of reactor-grade plutonium that includes 0.4 tonnes of safeguarded plutonium. . . . [T]he HEU produced by India is assumed to be enriched to between 30 percent and 45 percent uranium-235. Assuming an enrichment level of 30 percent, India is estimated to have a stockpile of 4.0±1.4 tons of HEU as of the end of 2016. . . . The total amount of weapon-grade plutonium in India's stockpile is estimated to be 0.58±0.15 tonnes."[63]

Currently, the Trombay reprocessing plant reprocesses the spent fuel from research reactors with the capacity of 60 tonnes per year.[64] The three large-scale plants for reprocessing of the thermal reactor spent fuel in India currently. The plants at Tarapur and Kalpakkam, each with an operating capacity of 100 tonnes per year, process off-site fuels from PHWRs. Moreover, a report from the Bhabha Atomic Research Center states that "additional reprocessing facilities are being set up with the active participation of the Indian industry to accelerate the programme".[65] India with more than 50 years of sustained reprocessing experience is poised to be a leader in the fast reactor with matured reprocessing technology.

[62] Nuclear Threat Initiative, "Not All Indian Fissile Material Being Used for Bombs: Analysts," July 25, 2012. https://www.nti.org/gsn/article/not-all-indian-fissile-material-being-used-bombs-analysts/

[63] International Panel of Fissile Materials, "Countries: India," February 12, 2018. https://www.nti.org/gsn/article/not-all-indian-fissile-material-being-used-bombs-analysts/

[64] Rajeev Sharma, "Coming to India's Aid on KNPP's Spent Nuclear Fuel," *India & Russia Report*, May 13, 2013. http://in.rbth.com/economics/2013/05/13/coming_to_indias_aid_on_knpps_spent_nuclear_fuel_24903.html

[65] Bhabha Atomic Research Center, *Indian Programme on Reprocessing*, http://www.barc.gov.in/publications/eb/golden/nfc/toc/Chapter%206/6.pdf

4. NUCLEAR SECURITY GOVERNANCE IN INDIA

In the consolidated National Progress Report presented at the 2016 Nuclear Security Summit held in Washington, D.C., India categorically states: "Nuclear industry and research centres in India have internalized security practices in their day-to-day working and have created a strong security culture in their respective organizations."[66] Similarly, a media briefing released by the Ministry of External Affairs (MEA) on the eve of the third NSS in 2014 proclaims: "India is no stranger to nuclear security. At the dawn of India's nuclear power programme, Prime Minister Nehru [mentioned] that source material for nuclear energy was not an ordinary commodity and needed to be handled with care."[67] The briefing further claims: "There has been no breach of nuclear technology security of the kind that allowed A Q Khan to access and proliferate sensitive nuclear technology and materials. . ." and, even more pertinently ". . . India's efforts to secure its nuclear materials, facilities and activities did not begin with the recent rise in international awareness about the dangers of nuclear terrorism."[68] The NSS process that brought momentum to "national action and responsibility for securing nuclear and radiological materials" has, according to an Indian commentator, "universalised a threat that India was fighting a lonely battle against" for the last few decades.[69] In tune with the current security requirements, especially during the last few years, India not only claims to have strengthened its own nuclear security architecture, but also participated in strengthening security architecture at the global level.

Prior to the establishment of the NSS process, India's AERB Safety Code of October 2009 defined nuclear security as "[a]ll preventive measures taken to minimize the residual risk of unauthorised transfer of nuclear material and/or sabotage, which could lead to release of radioactivity and/or adverse impact on the safety of the plant, plant personnel, public and environment."[70] In its 2014 media briefing, the Indian MEA described the concept of nuclear security as ". . . the prevention and detection of, and response to unauthorized removal, sabotage, unauthorized access, illegal transfer or other malicious acts involving nuclear or radiological material or their associated facilities."[71] Both definitions largely agree with the working definition of nuclear security used by the IAEA since 2003: "The prevention and detection of and response to theft, sabotage, unauthorized access, illegal transfer or other malicious acts involving nuclear material, other radioactive substances or their associated facilities."[72] India's notion of nuclear security is well aligned with global concerns. The former Prime Minister Manmohan Singh's acknowledgement at the 2010 NSS that "nuclear security is one of the foremost challenges we face today" and that the summit's process is in India's own interest, acknowledges that the threat to nuclear infrastructure is credible and India is conscious of

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66 "National Progress Report: India," *National Progress Reports*, 2016 Nuclear Security Summit, Washington, D.C., March 31, 2016. http://www.nss2016.org/document-center-docs/2016/3/31/national-progress-report-india

67 Government of India, Ministry of External Affairs, *Nuclear Security in India*, March 2014. https://www.mea.gov.in/in-focus-article.htm?23091/Nuclear+Security+in+India

68 Ibid.

69 Manpreet Sethi, "Fighting Nuke Threat is No Joke," *The New Indian Express*, May 1, 2014. https://www.newindianexpress.com/opinions/2014/may/01/Fighting-Nuke-Threat-is-No-Joke-606800.html

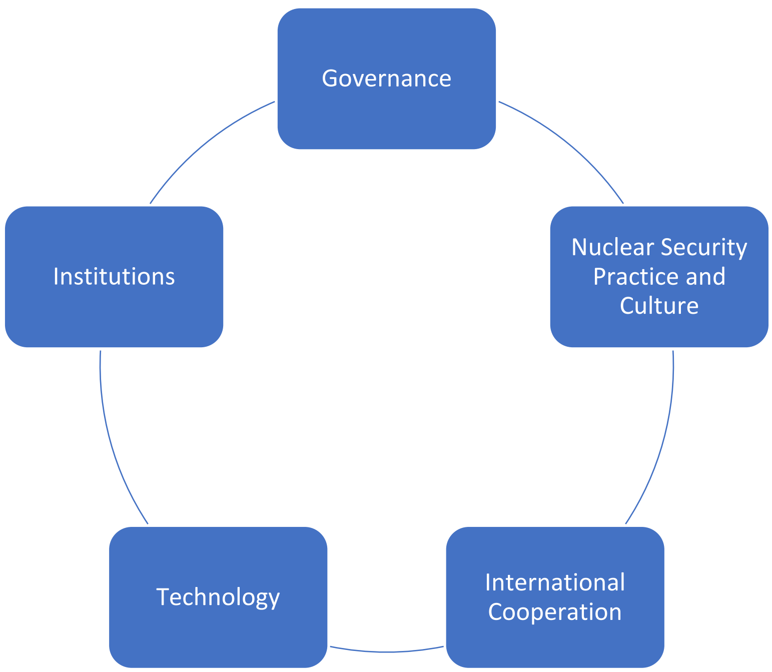
70 Atomic Energy Regulatory Board, *Glossary of Terms for Nuclear and Radiation Safety*, Guide NO. AERB/SG/GLO, March 2005, p. 43. https://aerb.gov.in/english/publications/codes-guides

71 Government of India, Ministry of External Affairs, *Nuclear Security in India*, March 2014. https://www.mea.gov.in/in-focus-article.htm?23091/Nuclear+Security+in+India

72 International Atomic Energy Agency, *Nuclear Security Plan 2010-2013*, GOV/2009/54-GC(53)/18, August 17, 2009, pp. 1-2. http://www.iaea.org/About/Policy/GC/GC53/GC53Documents/English/gc53-18_en.pdf

the issue. Given this recognition of the threat to nuclear security, India has been an enthusiastic partner of the NSS process to explore innovative approaches and best practices for nuclear security.

According to India's National Progress Report delivered during the 2016 NSS, since requiring nuclear energy a resource for electricity generation, India has seen "[c]ontinuous evolution of the framework for governance of nuclear power including that for nuclear security . . . ."[73] However, analysts have argued that "[f]or years, neither the Indian strategic community nor the Indian government paid serious attention to the problem of nuclear terrorism" in the public domain. Rather, the Indian government joined almost all international initiatives without engaging in any major domestic debate.[74] Information regarding India's approach towards nuclear security was largely confined to the nuclear establishment and government officials. The Indian strategic community took serious note of India's nuclear security strategy only in 2010, when the country's foreign policy establishment briefed the media, and Prime Minister Singh delivered his statement at the NSS in Washington, D.C. The MEA media briefing on the eve of the 2014 NSS broadly described five elements of India's approach to nuclear security: institutions: technology; nuclear security practice and culture; governance; and international cooperation (see Figure 2).



Source: http://www.mea.gov.in/Images/pdf/Brochure.pdf, p. 3.

Figure 2. Five Elements of India's Approach to Nuclear Security

[73] "National Progress Report: India," *National Progress Reports*, 2016 Nuclear Security Summit, Washington, D.C., March 31, 2016. http://www.nss2016.org/document-center-docs/2016/3/31/national-progress-report-india
[74] Rajiv Nayan, "India's Nuclear Security Policy," Institute for Defence Studies and Analyses, January 5, 2012. http://idsa.in/idsacomments/IndiasNuclearSecurityPolicy_rnayan_050112.html

4.1. Institutions: Roles and Responsibilities

Following India's independence, gained in 1947, the nation sought to advance their scientific capabilities in various fields. A special emphasis was placed on atomic energy. The government aimed to establish a strong foundation in atomic energy and therefore granted scientists and scholars in the field autonomy to recruit top talent.[75] The subsequent rapid growth of the atomic energy field necessitated the formation of regulatory agencies to lay the framework around which scientists could continue their pioneering work in the field. Such institutions, such as India's Atomic Energy Commission (AEC) and Department of Atomic Energy (DAE) infused funding and manpower into atomic energy initiatives.

India's atomic energy institutions are well established in the country and are pivotal in the regulation of the nuclear technology drive in the country. The Atomic Energy Commission (AEC), the top decision-making body on nuclear energy matters in India, was established in August 1948 within the Department of Scientific Research, which was itself set up in June 1948. The DAE, the promotional agency under which numerous specialized institutions scattered across the country operate, came into existence in August 1954 through a presidential order. Thereafter, a government resolution in 1958 transferred the DAE within the AEC. The Secretary to the Government of India in the DAE is the ex-officio Chairman of the AEC. Other members of the AEC are appointed on the recommendation of the Chairman of the AEC.[76] The regulatory body for civil nuclear installations in India is the AERB, which was established in 1983. The primary authority of the institution comes from the Atomic Energy Act of 1962, which provides direction for the development, control and use of atomic energy in addition to issue of rules and guidelines related to export controls.[77] Figure 3 shows the current institutional structure and organizational chart of India's atomic energy establishment.

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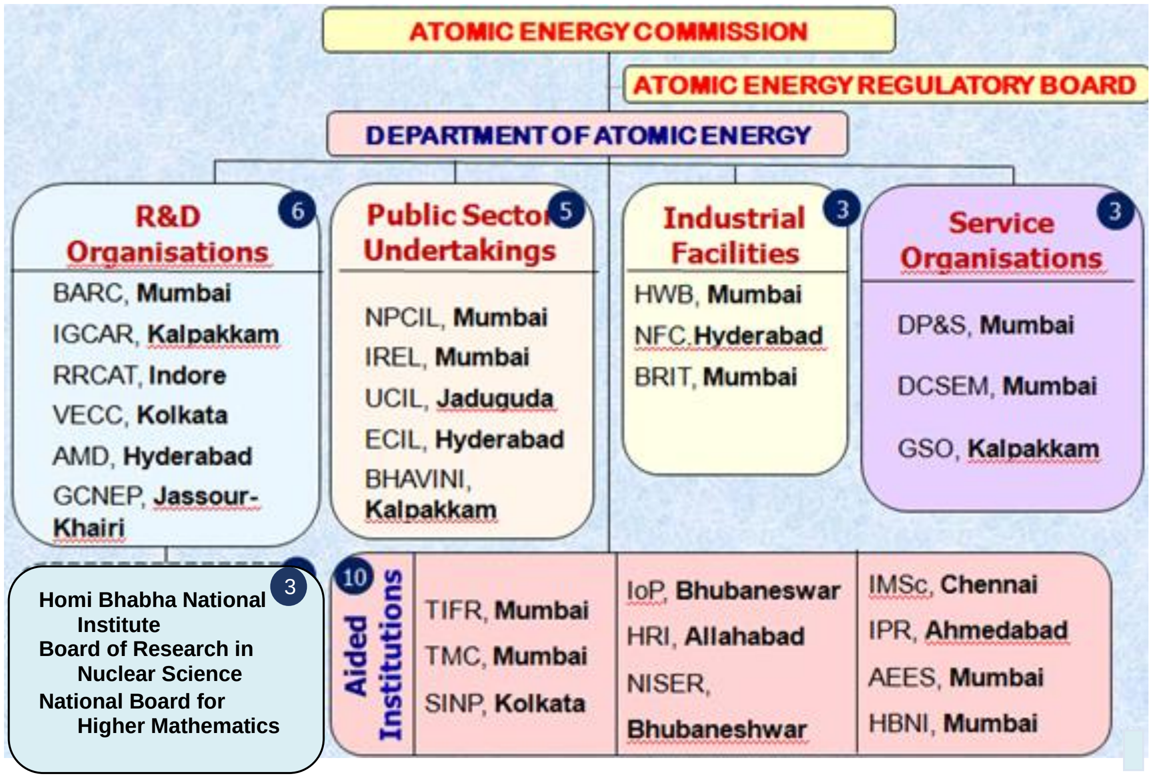
[75] India's Department of Atomic Energy: A Page in History. (n.d.). Retrieved from https://www.wilsoncenter.org/blog-post/indias-department-atomic-energy-page-history

[76] Government of India, Department of Atomic Energy, "Government of India Atomic Energy Commission." http://www.dae.gov.in/node/394

[77] The Atomic Energy Act, 1962, Available at *India Code, the Digital Repository of All Central and State Acts*. https://indiacode.nic.in/handle/123456789/1413?sam_handle=123456789/1362



Source: https://www-pub.iaea.org/MTCD/Publications/PDF/cnpp2018/countryprofiles/India/India.htm
(updated with authors' additions)

Figure 3. Organizational Structure of India's Nuclear Establishment

4.2. Legal and Regulatory Framework

In India, nuclear security and nuclear safety have traditionally been considered as two sides of the same coin; hence, the legislative framework and institutional architecture responsible for nuclear safety also supports nuclear security. The country's legislative framework for nuclear matters flows from the Atomic Energy Act 1962 passed by the Indian Parliament. As per the Act, the AEC is the sole authority in the country that deals with nuclear energy matters. Various rules have been established under the 1962 Atomic Energy Act, such as: (1) Atomic Energy (Working of Mines, Minerals and Handling of Prescribed Substance) Rules, 1984; (2) Atomic Energy (Safe Disposal of Radioactive Wastes) Rules, 1987; (3) Atomic Energy (Factories) Rules, 1996; (4) Atomic Energy (Control of Irradiation of Food) Rules, 1996; and (5) Atomic Energy (Radiation Protection) Rules, 2004. The AERB is legally empowered to enforce these rules.[78] In addition, the Manufacture, Storage and Import of Hazardous Chemical Rules (1989), under the 1986 Environmental Protection Act, also names the "AERB as the authority to enforce directions and procedures as per Atomic Energy Act with respect to radioactive substances."[79]

The regulatory body, AERB, was not set up by the Atomic Energy Act of 1962, but by a gazette notification by the government of India in 1983. The AERB is responsible for both the safety and security aspects of nuclear facilities and material. In the 1950s, prior to the establishment of the AERB, self-regulation by each facility was the norm. By the 1960s, safety monitoring and

[78] Ibid.

[79] Government of India, Atomic Energy Regulatory Board, Acts & Regulations, Rules. https://aerb.gov.in/english/acts-regulations/rules

surveillance was taken care of by the Health Physics Division and Directorate of Radiation Protection at the Bhabha Atomic Research Centre (BARC).[80] In 1972, the DAE established the Safety Review Committee to deal with nuclear energy matters and reporting to the Prime Minister.[81]

Institutionally, the security of nuclear and radiological material in India is ensured through robust oversight by the AERB. It reviews the safety and security of the country's operating nuclear power plants, nuclear power projects, fuel cycle facilities, and other nuclear/radiation facilities and radiation facilities.[82] The AERB periodically issues and updates safety and security related documents such as the "Nuclear Security Requirements for Nuclear Power Plants," the "Security of Radioactive Sources in Radiation Facilities," and the "Security of Radioactive Material During Transport." Following are some key nuclear security-related documents prepared by the AERB:[83]

- Nuclear Security Requirements for Nuclear Power Plants
- Guidelines for Reporting of Nuclear Security Events
- Checklist for Regulatory Inspection of Nuclear Power Plants
- Checklist for Regulatory Inspection of Nuclear Power Projects
- Procedure for Identification of Vital Areas
- Security of Radioactive Sources in Radiation Facilities (AER/RF-RS/RG1)
- Security of Radioactive Material during Transport (AERB/NRF-TS/SG-10)
- Safe Transport of Radiation Materials, AERB/NRF-TS/SC-1 (Rev.1), 2016
- Other documents under preparation
    - Security requirements for Heavy Water Plants
    - Security requirements for Nuclear Fuel Processing Facilities

Although the AERB specifies safety requirements through codes and guides, the safety and security of nuclear facilities and material, including their transport and disposal, is ultimately the responsibility of the individual operator. Indeed, the AERB has issued several guides for both safety and security of nuclear facilities and material. It ensures facility/user compliance with safety standards, as it controls the licensing process associated with setting up and running a nuclear facility. The AERB also conducts periodic reviews and inspections of the safety and security standards of nuclear power plants.

More importantly, since license is given to nuclear power plants for a maximum of five years, the renewal of a license requires a safety review of the plants. To efficiently conduct regulatory inspections involving both safety and security aspects of nuclear, industrial, and radiation facilities under AERB's regulatory purview, a separate dedicated Directorate of Regulatory Inspections has been formed within the AERB.[84] The AERB conducts monthly inspections of nuclear projects under construction, quarterly inspections for nuclear power projects, bi-annual inspections for

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[80] R. Bhattacharya, *Nuclear Regulatory Framework in India*, November 2012. http://www.abdan.org.br/download/encontro/india.pdf

[81] Ibid.

[82] Government of India, Atomic Energy Regulatory Board, "Highlight of Activities," *Annual Report 2018*, p. i. https://www.aerb.gov.in/images/PDF/Annual_report/ar2018/highlightsannualreport2018.pdf

[83] "Safety Documents", https://www.aerb.gov.in/images/PDF/chapter7.pdf

[84] Government of India, Atomic Energy Regulatory Board, *AERB Annual Report 2017*, pp. 47–48. https://www.aerb.gov.in/images/PDF/Annual_report/ar2017/annrpt2k17.pdf

operating plants, and yearly inspections for high-hazard radiation facilities.[85] During 2016–17 the AERB has conducted as many as 24 inspections in 8 nuclear facilities under construction; 43 inspections in 17 operating facilities and research reactors; 51 inspections in 22 industrial and fuel cycle facilities; and 15 security-specific inspections in 14 facilities (see Figure 4 and Table 3).[86]

Facility	No. of Inspection
FRFCF	1
DFRP	1
GHAVP	1
RAPP-7&8	1
MAPS	1
IGCAR (CORAL)	1
IGCAR (FBTR & IFSB)	1
TAPS-1&2	1
TAPS-3&4	1
NAPS	1
KKNPP-Site	2
PFBR	1
HWP-Kota & HWEAC	1
KAPP-3&4	1
Total	**15**

Source: AERB Annual Report 2017*, p. 51*

Figure 4. AERB Regulatory Inspections (Security Aspects)

Table 3. Regulatory Inspections by AERB during 2016-17

Facilities Under Construction		Operating Plants & Research Reactors		Industrial Fuel Cycle Facilities		Radiation Facilities	Security Aspects of 14 Facilities
Routine	Special	Routine	Special	Routine	Special	Routine+Special	15
19	05	36	07	49	02	1025	

Source: Compiled from AERB Annual Report 2017*, pp. 50-52.*

According to a report titled "Regulatory Inspections of Operating NPPs" released by the AERB in July 2019:

> "With an aim to increase regulatory oversight through increased field inspections, the inspection frequency of Operating NPPs has been revised since July 2017. AERB

[85] R. Bhattacharya, *Nuclear Regulatory Framework in India*, November 2012. http://www.abdan.org.br/download/encontro/india.pdf

[86] Government of India, Atomic Energy Regulatory Board, *AERB Annual Report 2017*, pp. 50–52. https://www.aerb.gov.in/images/PDF/Annual_report/ar2017/annrpt2k17.pdf

> has also started the Site Observer Programme to enhance its regulatory oversight and posted Site Observers at four [Nuclear Power Plant] NPP Sites (Rawatbhatta, Kakrapar, Kalpakkam, and Kudankulam) to observe & report important activities on a daily basis. Besides, special inspections (announced /unannounced) are conducted based on specific requirements."[87]

Further, "the security review structure in AERB has been restructured in September 2016, with the constitution of a Committee for Reviewing Security Aspects (CRSA) and a working group (CRSA-WG) under CRSA, for carrying out review of nuclear security aspects of nuclear power plants, security of radiation source in radiation facilities and during transport etc."[88] Especially "CRSA undertakes the detailed study to identify the security aspects related to safety (including cyber security related safety) which are required to be brought under the regulatory purview of AERB and submits recommendations to AERB."[89] It is also entrusted with the review of draft AERB regulatory documents and updating of existing documents related to security of nuclear and radiation facilities based on newly available information.[90]

4.2.1. Regulatory Framework Concerns

A major concern with any nuclear regulatory framework is the lack of autonomy of the regulator from the nuclear energy establishment. India's nuclear regulator, AERB, is arguably not an independent entity, as it depends on the government for funding and expertise and reports to the Atomic Energy Commission, of which the Chairperson is the Secretary of the Central Government's DAE. The government also appoints the regulatory body's head. As A. Gopalakrishnan, former head of the AERB, points out, "[W]e have almost all AERB Advisory Committees stacked with vast majority of Ex-DAE personnel, who all jointly skew their opinion mostly in the DAE's favour."[91] However, India's official reports assert that AERB is de facto independent and that it "enjoys full functional independence from DAE or any other agency in its functioning and its reporting to AEC is limited to presenting its Annual Report and Budget Proposals only once in a year. The Chairman AERB is the 'competent authority' under various rules promulgated under the Atomic Energy Act, 1962 on radiological safety."[92] More so, AERB's inspectors have often acted sternly against defaulting operators, illustrating that AERB is not a powerless body.

Indeed, these long-standing concerns have found a prominent place in reports by the Comptroller and Auditor General of India (CAG) and the Parliament of India's Public Accounts Committee. Both reports highlighted several institutional, safety, performance, and other related issues regarding nuclear regulation in India. Most of the concerns raised by these reports have direct or indirect

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[87] Government of India, Atomic Energy Regulatory Board, "Regulatory Inspections of Operating NPPs," July 2019. https://www.aerb.gov.in/images/PDF/NPP-RI-July-2019.pdf

[88] Government of India, Atomic Energy Regulatory Board, *AERB Annual Report 2017*. https://www.aerb.gov.in/images/PDF/Annual_report/ar2017/annrpt2k17.pdf

[89] Ibid, p. 2.

[90] Ibid.

[91] A. Gopalakrishnan, "Nuclear Safety Regulator: The US Model," *DNA*, December 13, 2011. http://www.dnaindia.com/analysis/column-nuclear-safety-regulator-the-us-model-1624980

[92] Government of India, Atomic Energy Regulatory Board, "National Report to the Convention on Nuclear Safety: Seventh Review Meeting of Contracting Parties, March 2017," p. 48, August 2016. https://aerb.gov.in/english/convention-on-nuclear-safety

implications for the larger issue of nuclear security. The CAG report of 2012–13 submitted to the President of India reported the following problems with the functioning of the AERB:[93]

- "The legal status of AERB continued to be that of an authority subordinate to the Central Government, with powers delegated to it by the latter.
- AERB did not have the authority for framing or revising the rules relating to nuclear and radiation safety.
- The maximum amounts of fines were too low to serve as deterrents against offences/contraventions related to nuclear and radiation facilities, which involve substantial risks. Further, AERB had no role in deciding the quantum of penalties and no powers with regard to imposition of the same.
- The consenting process and system for monitoring and renewal were found to be weak in respect to radiation facilities. This led to a substantial number of radiation facilities operating without valid licenses."

Following up on the CAG report, which was clearly critical of the nuclear governance structures in India, the Public Accounts Committee of the Indian Parliament (2013-2014) carried out a sustained inquiry into the activities of the AERB and submitted a report entitled "Activities of the Atomic Energy Regulatory Board" to the Parliament in November 2013. The report reaches conclusions that are very similar to those of the CAG report. The following are some of its conclusions:[94]

- The Committee observes that the failure to have an autonomous and independent regulator is clearly fraught with grave risks.
- Regarding the proposed Nuclear Security Regulatory Bill currently pending in the Parliament – The Committee recommends that the DAE should seriously re-examine the provisions of the Bill and take necessary steps urgently to ensure that the nuclear regulator becomes an independent and credible body on par with similar regulators in other countries.[95]
- The Committee are concerned to note that AERB did not have any authority for framing rules relating to nuclear and radiation safety as the rule-making power under Section 30 of the AE Act, 1962 vests with the Central Government, that is, with the DAE and the AERB is involved in the consultative process.[96]
- The Committee are concerned to note that there is an acute shortage of Radiological Safety Officers, who are required to be designated for all radiation units in accordance with the provisions in Rule 22 of RPR, 2004 and Rule 13 of Safe Disposal of Radioactive Waste Rules, 1987. . . . the Committee observe that effectiveness of safety procedures remains deeply compromised due to their acute shortage. The Committee are concerned to find that

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93 Government of India, Comptroller and Auditor General of India, "Executive Summary," *Report No. 9 of 2012 - Performance Audit on Activities of Atomic Energy Regulatory Board Union Government, Atomic Energy*. 2012. https://cag.gov.in/content/report-no-9-2012-performance-audit-activities-atomic-energy-regulatory-board-union
94 Government of India, Public Accounts Committee 2013–2014, "Activities of Atomic Energy Regulatory Board," Report No. 90, p. 47. Released on December 9, 2013, http://www.indiaenvironmentportal.org.in/files/file/Performance%20audit%20on%20activities%20of%20Atomic%20Energy%20Regulatory%20Board.pdf. http://164.100.47.134/lsscommittee/Public%20Accounts/15_Public_Accounts_90.pdf
95 Ibid., p. 48.
96 Ibid., p. 49.

there was acute shortage of not only RSOs but also of trained manpower in general in AERB.[97]

- The Committee notes with profound concern that off-site emergency exercises carried out highlighted inadequate emergency preparedness even for situations where the radiological effects of an emergency originating from NPP are likely to extend beyond the site and affect the people around.[98]

4.2.2. The Nuclear Safety Regulatory Authority Bill

As pointed out earlier, the government of India took steps to convert the de facto independence of AERB (as per the government claim) to de jure autonomy through the NSRA.[99] However, questions remain about the autonomy of the new body.

The NSRA bill was presented to the Lok Sabha in September 2011 and was subsequently referred to a Department-Related Parliamentary Standing Committee on Science & Technology, Environment & Forests in the same month. Standing Committees are permanent committees made up of Members of Parliament that can be congregated when the Parliament is faced with a high volume of complex legislative issues.[100] The Committee gave its report in March 2012 and, according to reports, the government (DAE) adopted most of the suggestions and sent it back to the Parliament.[101] Among other issues, the bill suffers from the fact that it is dependent on the government for funding and appointment of staff. Moreover, the Council of Nuclear Safety to be established by the NSRA bill—with the Prime Minister as the Chair and mostly government representatives as members—will be a powerful body with the power to appoint the chairperson and members of the new regulatory body. This will diminish the powers of the regulator, making it will subordinate to the Council.

Analysts have also critiqued the various provisions of the bill. For instance, Suvrat Raju and M. V. Ramana argued that the clause "the decision of the central government whether a question is one of policy or not shall be final" is problematic since "if a pesky Authority questions, say, the decision to import an untested nuclear reactor, the government can silence it simply by declaring that the matter is one of 'policy.' This clause profoundly undermines the independence of the Authority."[102] According the Raju and Ramana, the appointment process is also faulty: Another structural problem with the proposed NSRA is that all its members will be 'appointed by the central government on the recommendations of the search committees.' However, "these committees will be constituted by the Council of Nuclear Safety, which will comprise seven Union Ministers, the Secretary of the DAE, and the Cabinet Secretary. So, in effect, the government will have complete control over the appointment process and can use it to appoint pliant technocrats."[103]

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[97] Ibid., p. 55.
[98] Ibid., p. 56.
[99] For a copy of the bill see, http://www.prsindia.org/uploads/media/Nuclear%20Safety/Nuclear%20Safety%20Regulatory%20Authority%20Bill%202011.pdf
[100] PARLIAMENTARY COMMITTEES. (n.d.). Retrieved from https://web.archive.org/web/20120724034114/http://www.parliamentofindia.nic.in/ls/intro/p21.htm
[101] "Nuclear Safety Bill to be Taken up in Next Session: Minister," September 06, 2013, *ZeeNews*. http://zeenews.india.com/news/nation/nuclear-safety-bill-to-be-taken-up-in-next-session-minister_874653.html
[102] Suvrat Raju and M. V. Ramana, "It's Better to be Safe than Sorry," *Hindustan Times*, February 5, 2014. http://www.hindustantimes.com/comment/analysis/it-s-better-to-be-safe-than-sorry/article1-1180454.aspx
[103] Ibid.

The NSRA, at least in its current form, does not elaborate on which facilities would be put under the new authority; currently, only the AERB can oversee civilian facilities.[104] If that continues under the new law, it is uncertain who will oversee the safety and security of the strategic facilities and programs. The bill mentions that new regulatory bodies can be created to regulate the strategic programs (clause 25, Sub-clause (2) of the bill). However, there has been no movement to do so as of now. After the bill was introduced in the Parliament in 2011, the Parliamentary Standing Committee gave its recommendations on the bill, some, but not all, of which were incorporated by the DAE. Talking about the bill, the Minister in the Prime Minister's Office, Mr. Narayanaswamy had said in 2013 that "the government adopted majority of the recommendations given by the committee and it has now come to the Lok Sabha."[105] However, with the end of the term of the 15th Lok Sabha, the bill has lapsed. For such an initiative to resume, the government will have to restart the process all over again but no interest is visible yet on the part of the current regime.

This is not to argue that the suggested NSRA is not an improvement from the existing AERB. Indeed, there are significant differences between the two. For one, while the AERB was set up by a government order, the new regulator under NSRA will be established by an Act of the Parliament, making it more powerful. Moreover, while the AERB was bound to report to the AEC and indirectly to the DAE, the new authority will not report to the AEC and will submit its report to the Parliament.

The NSRA bill is currently lapsed, and the new government needs to reintroduce the ill in the legislature. The Committee in its report[106] asked the government to ensure that the regulatory authority is made more autonomous. The Public Accounts Committee made the same recommendation to the government: "The department of atomic energy should seriously re-examine provisions of the Bill and take necessary steps to ensure the nuclear regulator becomes independent and credible and at par with regulators in other nations."[107]

While the proposed NSRA was a step in the right direction for India, little progress has been made since the bill was tabled in the Indian Parliament in September 2011.

4.3. India and the Global Nuclear Security Regime

India is an active participant in the global nuclear security regime. New Delhi is committed to fighting terrorism in all its forms, and, hence, it is party to "all the 13 universal instruments accepted as benchmarks for a State's commitment to combat international terrorism," including the International Convention for the Suppression of Acts of Nuclear Terrorism (ICSANT).[108] India has ratified the Convention on the Physical Protection of Nuclear Material (CPPNM) as well as its 2005 amendment. It has also expressed its support for the fifth revision of IAEA's INFCIRC/225. India

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104 A. Gopalakrishnan, "Transparency in Nuclear Safety Regulation," *DNA*, February 2, 2012. http://www.dnaindia.com/analysis/comment-transparency-in-nuclear-safety-regulation-1644896India

105 "Nuclear Safety Bill to be Taken up in Next Session: Minister," *ZeeNews*, September 6, 2013. http://zeenews.india.com/news/nation/nuclear-safety-bill-to-be-taken-up-in-next-session-minister_874653.html

106 Government of India, Department-related Parliamentary Standing Committee on Science & Technology, Environment & Forests, "Two Hundred and Twenty First Report on the Nuclear Safety Regulatory Authority Bill, 2011," March 6, 2012. http://www.prsindia.org/uploads/media/Nuclear%20Safety/NSRA%20Bill%202011_%20Standing%20Com%20Report.pdf

107 Ibid, p. 48.

108 Government of India, Ministry of External Affairs, *Nuclear Security in India*, March 2014. https://www.mea.gov.in/in-focus-article.htm?23091/Nuclear+Security+in+India

adheres to the IAEA Code of Conduct on the Safety and Security of Radioactive Sources and the NSG guidelines on nuclear transfers.[109]

There is a perceptible increase in the country's confidence which is reflected in its willingness to open its facilities for international inspection and review. India has been forthcoming, especially after the 2008 India-IAEA agreement, with the safety review of India's nuclear facilities. India's civilian nuclear power plants were reviewed by the Operational Safety Review Team (OSART) of the IAEA and the World Association of Nuclear Operators (WANO). While the Indian nuclear reactors have been under WANO peer review for some time—NPCIL is a member of WANO—they were reviewed for the first time in 2012 by OSART.[110] India has also invited the Integrated Regulatory Review Service (IRRS), the Peer Review Mission of IAEA, to review India's nuclear power plants.[111] The IRRS peer review usually assesses both safety and security.[112] The IAEA-IRRS Mission visited India March 16–27, 2015. The IRRS team comprised 16 experts from the nuclear regulatory authorities of Bulgaria, Canada, Czech Republic, Finland, Hungary, Israel, Netherland, United Kingdom, United States of America, and the IAEA itself. The IRRS team, while acknowledging the good practices followed, made 21 recommendations to further strengthen India's current regulatory framework including independence of the regulatory body in the law.[113] In addition, India has been cooperating with Interpol's Radiological and Nuclear Terrorism Prevention Unit.[114]

India has clearly been steadfast in its adherence to the instruments and norms stipulated by the global nuclear security regime. It has not only adopted the UNSC Resolution 1540 (as well as its extension Resolution 1977) but has taken measures to implement its recommendations. An exhaustive report of the Ministry of External Affairs affirms India's role in the nuclear security regime:

> "India participates in the IAEA's Illicit Trafficking Database (ITDB), which was established in 1995 and disseminates information on confirmed reports about illicit trafficking and other unauthorized activities and events involving nuclear radioactive materials to the States. Since 2007, India is a party to the Global Initiative to Combat Nuclear Terrorism and has participated in its working groups on nuclear detection, nuclear forensics and response and mitigation. India also cooperates with the Interpol's Radiological and Nuclear Terrorism Prevention Unit and the World Customs Organization on nuclear trafficking issues."[115]

India has also been attempting to adjust the country's domestic laws to match the legal provisions, practices, and expectations of the international nuclear order. India passed the Chemical Weapons

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[109] Ibid.

[110] "IAEA Experts to Begin Review of Nuclear Plants in Rajasthan Tomorrow," *The Times of India*, October 29, 2012. http://timesofindia.indiatimes.com/india/IAEA-experts-to-begin-review-of-nuclear-plants-in-Rajasthan-tomorrow/articleshow/17003100.cms

[111] "Indian Atomic Energy Regulator Readying for IAEA Review," *DNA*, March 4, 2014. http://www.dnaindia.com/india/report-indian-atomic-energy-regulator-readying-for-iaea-review-1966844

[112] International Atomic Energy Agency, "Integrated Regulatory Review Service." https://www.iaea.org/services/review-missions/integrated-regulatory-review-service-irrs

[113] Government of India, Atomic Energy Regulatory Board, "National Report to the Convention on Nuclear Safety: Seventh Review Meeting of Contracting Parties, March 2017," p. 52, August 2016. https://aerb.gov.in/english/convention-on-nuclear-safety

[114] Government of India, Press Information Bureau, "Nuclear Security Summit National Progress Report India," Press statement released March 27, 2012. http://pib.nic.in/newsite/PrintRelease.aspx?relid=81755

[115] Government of India, Ministry of External Affairs, *Nuclear Security in India*, March 2014. https://www.mea.gov.in/in-focus-article.htm?23091/Nuclear+Security+in+India

Convention Act in 2000 and subsequently amended it in 2010. The law was enacted "to give effect to the convention on the prohibition of the development, production, stockpiling and use of chemical weapons and on their destruction. India had signed the convention on January 14, 1993."[116] The country enacted The Weapons of Mass Destruction and Their Delivery Systems (Prohibition of Unlawful Activities) Act in 2005[117] "to fulfill India's obligations under the United Nations Security Council Resolution 1540 of April 28, 2004."[118] The Act "authorizes the GOI to regulate the export, re-transfer, re-export, transit, and transshipment of any items related to the development, production, handling, operation, maintenance, storage, or dissemination of a weapon of mass destruction (WMD) or missile delivery device. It also established a catch-all control that restricts exports of non-listed items destined for a WMD end-use, and it provided a rudimentary legal basis to regulate technology transfers."[119]

Further, the Foreign Trade Development and Regulation Act (FTA) No. 22 of 1992 (amended in 2010) provides the legal basis for India's strategic trade control system. The FTA "empowers the Directorate General of Foreign Trade (DGFT), situated within the Department of Commerce and Industry, to license the export and import of items on the Indian Tariff Classification (Harmonized System) or ITC (HS) list."[120] This legal instrument was further strengthened by the Weapons of Mass Destruction Act 2005.

4.3.1. Global Centre for Nuclear Energy Partnership

In fulfilling the promise made by India at the inaugural Nuclear Security Summit, it has established the Global Centre for Nuclear Energy Partnership (GCNEP) with a view to "help in capacity building, in association with the interested countries and the IAEA, involving technology, human resource

AREAS OF R&D BY GCNEP

- Sensors and systems for security applications
- Systems for personnel and material access control, intrusion detection
- Personnel reliability studies
- Surveillance, video analytics and advanced video tools
- Explosives and other contraband detection
- Radiation detection equipment
- Vulnerability studies
- Nuclear security computer simulation
- Secure transportation
- Safeguard systems, including seals, tags, containment and surveillance
- Material accounting and control
- Seismic and other monitoring
- Regulatory studies

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[116] "Lok Sabha Passes Chemical Weapons, AIIMS Bills," *Ndtv.com*, Aug [illegible] news/lok-sabha-passes-chemical-weapons-aiims-bills-498170

[117] Government of India, Ministry of External Affairs, The Weapons of Mass Destruction and their Delivery Systems (Prohibition of Unlawful Activities) Act, 2005. http://www.mea.gov.in/Uploads/PublicationDocs/148_The-Weapons-Mass-destruction-And-Delivery-Systems-Act-2005.pdf

[118] R. Ramachandran, "A Bill and Nuclear Hopes," *Frontline*, Vol. 22, Issue 12, Jun 4-17, 2005. http://www.frontline.in/navigation/?type=static&page=flonnet&rdurl=fl2212/stories/20050617003102900.htm

[119] Government of India, Ministry of External Affairs, "The Weapons of Mass Destruction and their Delivery Systems (Prohibition of Unlawful Activities) Act, 2005." http://www.mea.gov.in/Uploads/PublicationDocs/148_The-Weapons-Mass-destruction-And-Delivery-Systems-Act-2005.pdf

[120] "India's Export Controls: Current Status and Possible Changes on the Horizon," *SECURUS Strategic Trade Solutions*, 2011. http://securustrade.com/Indias_Export_Controls_Article_July_2011_FINAL.pdf

development, education & training and giving a momentum to R&D in enlisted areas." Established in 2010, the center currently has five schools, including one School on Nuclear Security Studies (SNSS) with the mission "to impart training to security agencies on application of physical protection system and response procedure, to enhance physical security of nuclear facilities by developing and deploying most modern technological tools including information security and to provide facilities for test and evaluation of sensors and systems used for physical security."

This school of excellence is mandated "to provide a world class research and development, test and evaluation, information security, training and exercise facility for different areas of nuclear security to national and international audience."[121] The center is designed to test various systems and sensors used for nuclear security applications for their performance and effectiveness with real time scenario. In addition, computer security methodologies will be developed for protection of information related to entire nuclear fuel cycle activities including that of nuclear security. The center is also assigned to train the concerned security personnel on such topics as the application of physical protection systems and response procedures. From 2011 to May 2019, the center has conducted 26 such training courses and programs in collaboration with international partners.[122]

AREAS OF R&D BY SNSS

- Sensors & systems for security applications
- Systems for personnel and material access control, intrusion detection
- Personnel reliability studies
- Surveillance & video analytics & advanced video tools
- Explosives & other contraband detection
- Radiation Detection Equipment
- Vulnerability studies
- Nuclear security computer simulation
- Secure transportation
- Safeguard systems like seals, tags, containment & surveillance
- Material accounting & control
- Seismic & other monitoring
- Regulatory studies

Source: www.gcnep.gov.in/schools/snss.html

4.3.2. Nuclear Security Summits and India's Commitment

India's highest authorities have participated in all Nuclear Security Summits, underscoring the country's commitment to national nuclear security. There is no division of opinion in India on the importance of nuclear security and India's commitment towards the NSS obligations. The 2010 NSS Work Plan aimed at universalizing such multilateral instruments as ICSANT, CPPNM, UNSCR 1540, and UNSCR 1373, with which India is fully compliant. The Seoul Summit 2012 expanded the scope of nuclear security to include radiological source security and expected voluntary commitments in the form of 'house gifts'/'gift baskets' from members to do more than the political consensus process. India fulfilled its obligation made at the inaugural NSS to establish a center of excellence (GCNEP) focused on the development of enhanced nuclear safeguards to effectively and efficiently monitor nuclear materials and facilities. India is engaged in cooperation with the US, Russia, France, and the IAEA to develop advanced, proliferation-resistant nuclear power reactors in addition to other innovative projects.

[121] Ibid.

[122] Global Centre for Nuclear Energy Partnership, "Programs." http://www.gcnep.gov.in/programs/programs.html

INDIA'S NSS COMMITMENTS

- Participated in all Summits
- Gift basket – GCNEP
- No research reactor uses HEU
    - APSARA nascent rector has been placed in a "safeguarded" facility
- Adheres to all multilateral legal commitments
    - ICSANT, CPPNM, GICNT, IAEA Code of Conduct reviewed by the OSART-WANO, ITDB
- Domestic legislation with international compliance
    - Foreign Trade Act 2010
    - SCOMET list updated
- Financial contribution to Nuclear Security Fund

The 2014 NSS in The Hague suggested enhanced cooperation in areas relating to cyber security and emergency response, which India is pursuing wholeheartedly. India has contributed financially to the Nuclear Security Fund. India pledged and embarked on strengthening the implementation of nuclear security through subscribing to the 2014 Joint Statement on Strengthening Nuclear Security Implementation (INFCIRC 869). The only research reactor in India using highly enriched uranium (HEU) has been shut down, and the planned replacement reactor will not use HEU. The last NSS (2016) in Washington, D.C. was viewed as a "transition summit" to plan how to sustain the nuclear security momentum. India is a member of the Nuclear Security Contact Group which convenes annually to discuss a broad range of nuclear security-related issues including promotion of implementation of commitments.

4.4. The Physical Protection System

India shares the global concerns on nuclear security and follows a 'cradle to grave' principle of security for nuclear materials and associated facilities. Keeping in mind the allegation by the NTI that India's nuclear security and control measures are "average" and below those of Pakistan, the sections that follow explore the physical security system in place in India's nuclear installations based on open source information.

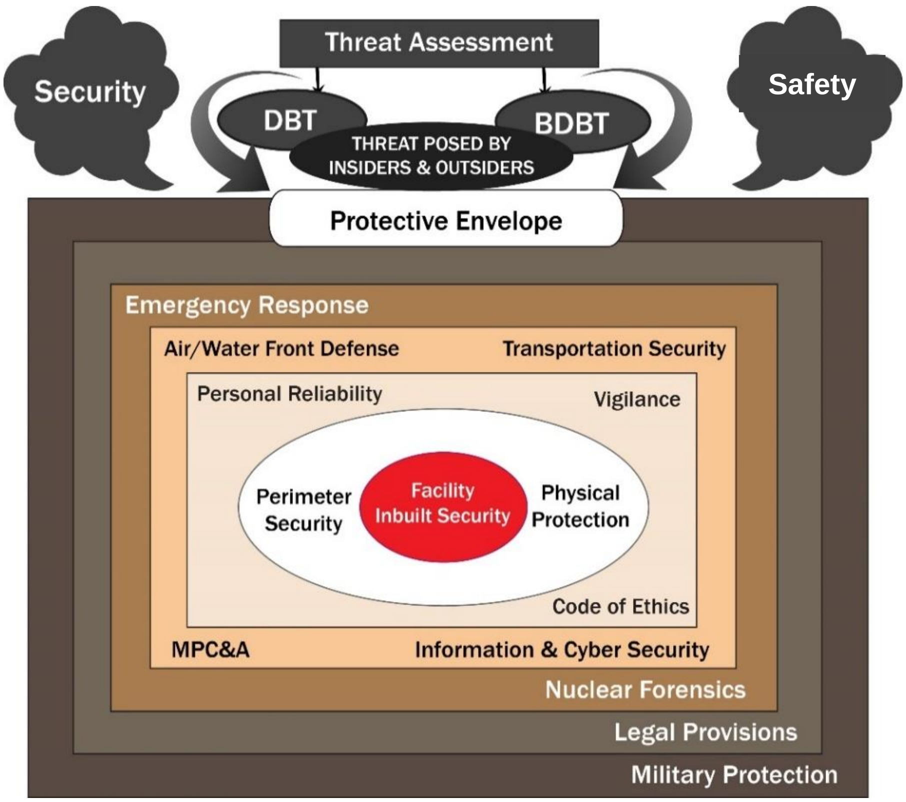
The physical security of India's nuclear infrastructure has many dimensions: (1) the nature of the nuclear program itself—their unique closed fuel cycle, which is argued to be inherently secure; (2) the technological dimension, where India is known to have made many technological advances to respond to any contingency; (3) the human dimension, where the country maintains an impeccable record; (4) the facility—specific physical security systems that it has developed in and around its nuclear installations; (5) India's experience in managing terrorism given the regional security environment; and (6) most importantly, the safe-keeping of its nuclear arsenal.

The nuclear security architecture of India's nuclear infrastructure is based mainly on five pillars:

1. National legal provisions in consonance with IAEA guidelines;
2. An oversight agency (AERB) that stipulates the SOPs;
3. The security (and intelligence) agencies in charge of threat assessment and physical protection;

4. The human element (personnel) with the responsibility for oversight or observance; and
5. Surveillance and detection technology for detection, delay, and response approach.

The oversight agency, AERB, has prescribed the technical basis with which to establish security levels—a 'graded approach'[123]—for ensuring the safety of radioactive materials during all stages of their handling in its guidelines on "Security of Radioactive Sources in Radiation Facilities."[124] In India's case, safety and security aspects of radioactive/nuclear materials are intimately linked and many of the measures designed to address safety also address security. Typically, the physical protection system (PPS) around Indian nuclear facilities is designed on the basis of their threat assessment,[125] taking into account the Design Basis Threat (DBT) and Beyond DBT to create a layered protective envelope consisting of inbuilt reactor security, perimeter security, personnel reliability, material protection and accounting, transportation security, air and water front defense, emergency preparedness, legal provisions, and, in extreme situations, military protection.



Source: Sitakanta Mishra, "Contours of India's Nuclear Safety," Air Power*, Apr–June 2011 (adapted and updated)*

Figure 5. The Security Envelope

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123 The 'Graded Approach' to security is based on the vulnerability analysis for a specific source, facility, or activity such as transportation. Assessment is made of the level of risk involved. Depending on the degree or level of risk involved, the security measures required to protect the source is determined. The higher the risk, the more capable security systems are required. Based on the security threat associated with radioactive sources, four security levels—A, B, C and D—have been defined. It must be emphasized that these security levels do not themselves define the security guidelines or measures.

124 Government of India, Atomic Energy Regulatory Board, "Security of Radioactive Sources in Radiation Facilities," *AERB Safety Guide*, AERB/RF-RS/SG-1, March 2011. http://www.aerb.gov.in/AERBPortal/pages/English/t/publications/CODESGUIDES/SG-RF-RS-01.pdf

125 Design basis threat assessment is normally done by government agencies such as Ministry of Home, Intelligence Bureau, Ministry of External Affairs, Law Enforcement Agencies, Cost Guards and Customs, Regulatory Authorities and other agencies with security related responsibilities.

4.4.1. Inbuilt Security

Indian nuclear plants are characterized by a high level of built-in safety and security features, which make them relatively less vulnerable to sabotage. According to Rajesh Basrur and Friedrich Steinhäusler, "[T]he large-volume, low-pressure, low-temperature moderator surrounding the pressure tubes keeps the risk of a fuel meltdown low. The steam generators are positioned well above the core, which promotes natural thermosyphoning (heat movement) in case shutdown cooling is lost. In addition, the CANDU plants are enclosed by heavy concrete walls, including a reactor vault of a minimum four feet thickness surrounding the nuclear core itself."[126] Reactors like the Kaiga-1 and 2, Rajasthan-3 and 4, and Tarapur-3 and 4 are housed in double containment domes. The domes are made of "microsilica-based high performance concrete;" they also have other added safety features like the automatic, "quick acting poison injection system to shut down the reactor in an emergency".[127]

The primary inner containment of the reactor is "designed to withstand the 'design basis' accidents" like assumed loss of coolant leading to reactor blackout; the secondary containment envelops the inner containment, and "the annulus between the two containment walls is maintained under vacuum, with a provision of continuous monitoring for any accidental release of radioactivity"[128] To avoid accidents caused by external missiles such as aircraft impact, adequate care is taken to exclude this event with proper siting criteria and selecting a safe screen distance value (SDV). During site selection, if the site falls within SDV for different types of airfields, a "probabilistic study of aircraft crashing" on the installation (considering flight frequencies) are carried out. If this probability is not acceptably low, the site is considered unsuitable for establishing NPP.[129] According to a study conducted by Mukesh Kukreja, et al. of the Reactor Safety Division, BARC, on the damage evaluation of the 500 MWe PHWR's containment for aircraft impact, such an event would cause only local deformation; the double containment is capable of absorbing the full impulsive load.[130]

India's unique three-stage nuclear program (based on the closed fuel cycle) is said to promote the security of nuclear materials. According to India's Ministry of External Affairs, the 'reprocess to reuse' approach "avoids both the build-up of stockpiles, as well as the need to store large amounts of spent fuel in underground repositories that could turn into easy to access plutonium mines for malefactors in the future."[131] In order to eliminate chances of terrorists' access to high-level nuclear waste, India follows the vitrification method for nuclear waste management. India is also working on design and deployment of proliferation resistant reactor designs such as the Advanced Heavy Water

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126 Rajesh M. Basrur and Friedrich Steinhäusler, "Nuclear and Radiological Threats for India: Risk Potential and Countermeasures," *The Journal of Physical Security*, Vol. 1, Issue 1, 2004, p. 7. http://jps.anl.gov/vol1_iss1/3-Threats_for_India.pdf

127 Government of India, Department of Atomic Energy, "Reactor Unit-3 of RAPP Commences Commercial Power Generation," *Nuclear India*, Vol. 34, No.1–2, July–Aug 2000. http://www.dae.gov.in/node/171

128 Mukesh Kukreja, et al., "Damage Evaluation of 500 MWe Indian Pressurized Heavy Water Reactor Nuclear Containment for Air Craft Impact," *Proceedings of the 17th International Conference on Structural Mechanics in Reactor Technology (SMiRT 17)*, Prague, Czech Republic, August 17–22, 2003, p. 1; also see, B.N. Rao, et al., "Reliability Analysis of 500 MWe PHWR Inner Containment Using High-Dimensional Model Representation," *International Journal of Pressure Vessels and Piping*, Vol. 87, 2010, pp. 230–238.

129 Roshan A.D., Shylamoni P., and Sourav Acharya, *Monograph on Siting of Nuclear Power Plants*, AERB, Civil & Structural Engineering Division, p. 13. https://aerb.gov.in/english/publications/monographs

130 Mukesh Kukreja, et al., "Damage Evaluation of 500 MWe Indian Pressurized Heavy Water Reactor Nuclear Containment for Air Craft Impact," *Proceedings of the 17th International Conference on Structural Mechanics in Reactor Technology (SMiRT 17)*, Prague, Czech Republic, August 17–22, 2003,

131 Government of India, Ministry of External Affairs, *Nuclear Security in India*, March 2014. https://www.mea.gov.in/in-focus-article.htm?23091/Nuclear+Security+in+India

Reactors (AHWRs), based on thorium and low enriched uranium (LEU), which is associated with the high-energy gamma-emitter U-232, known as AHWR300-LEU, which makes it intrinsically proliferation resistant.[132] Responding to the global concern for security of HEU in research reactors, "the enriched uranium based fuel in the APSARA nascent reactor has been placed in a "safeguarded facility in 2010. APSARA will use indigenous fuel which is not high enriched uranium."[133] At present no research reactor in India is operating with HEU.

4.4.2. Physical Protection

According to the AERB's annual report, at the operational level, "the AERB is entrusted with the responsibility of review and assessment of nuclear security aspects for different types of civil nuclear facilities in India."[134] For safety as well as security, it prescribes guidelines to be followed by plants in accordance with IAEA stipulations. An Advisory Group of Experts help in reviewing the implementation of these guidelines. The AERB has also been entrusted with the responsibility to ensure that a licensee takes adequate measures towards security.[135] To carry out review of nuclear security aspects related to the safety of Indian nuclear facilities, India's nuclear establishment has adopted a graded approach.[136] As mentioned earlier, the security review structure of AERB was rearranged in 2016 incorporating new specialized wings – a Committee for Reviewing Security Aspects (CRSA) and a working group (CRSA-WG) under CRSA.

Security preparedness starts with the preparation of a DBT assessment, and India has a confidential DBT for PPS design for all civilian nuclear facilities. The DBT assessment addresses the threat from terrorists, activists, and demonstrators who are capable of causing havoc, and the "internally motivated or externally coerced passive or active, and nonviolent or violent" 'insider threat'.[137] In addition, all facilities are required to prepare a facility-specific (local) threat assessment document to be considered during the design phase of every facility. Taking these aspects into consideration, "an integrated physical protection system (PPS) is in place in all nuclear installations and is a prerequisite for new builds" in India using the correct mix of security hardware, procedures, and trained personnel to restrict unauthorized easy access to sensitive areas.[138]

Every facility is surrounded by two fences—inner and outer—having multiple-layer security structure. As mentioned earlier, to prevent inadvertent or unauthorized access to radioactive sources or the facility, many state-of-the-art technical measures composed of hardware, security devices, and electronic security systems such as fences, walls, rooms/vaults, cages, transport packaging, locks and

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[132] Bhabha Atomic Research Centre, Department of Atomic Energy, "AHWR300-LEU: Advanced Heavy Water Reactor with LEU-Th MOX Fuel." http://www.barc.gov.in/reactor/ahwr.html

[133] PIB, Government of India, "Nuclear Security Summit National Progress Report India", March 27, 2012, https://pib.gov.in/newsite/PrintRelease.aspx?relid=81755

[134] Government of India, Atomic Energy Regulatory Board, "Safety Surveillance of Nuclear Facilities," *AERB Annual Report 2016*, p. 1. https://aerb.gov.in/images/PDF/Annual_report/ar2016/chapter1.pdf

[135] S.S. Bajaj, "Regulatory Practices for Nuclear Power Plants in India," *Sadhan*, Vol. 38, Part 5, October 2013, pp. 1044–45. http://www.ias.ac.in/sadhana/Pdf2013Oct/13.pdf

[136] Government of India, Atomic Energy Regulatory Board, *AERB Annual Report 2016*.

[137] Ranajit Kumar, "Technologies and Physical Security of Nuclear Materials: An Indian Perspective," in the National Academy of Sciences compiled *India-United States Cooperation on Global Security: Summary of a Workshop on Technical Aspects of Civilian Nuclear Materials Security (2013)*, Washington, D.C.: The National Academies Press, 2013, p. 62.

[138] Ibid, p. 64.

interlocks for doors with alarm systems, intrusion-resistant source-holding devices, surveillance cameras, etc. are in place.[139]

The Perimeter Protection and Command Control System[140] is in place at every nuclear facility in India. This system incorporates three concentric security zones, known as the 'perimeter security' system (see Figure 6). While its main goal is to encourage efficient emergency response and relief operations, it simultaneously enhances plant security. The size of the concentric zones varies depending upon the type or generation of reactor technology at the facility. The inner most circle (O–A) is the Plant Station Area. The second circle (O–B) is the Exclusion Zone, which starts at the inner fence of the Plant Station Area. This area is under the direct control of the plant administration, with two rings of security deployed with sophisticated surveillance systems. Public habitation is not allowed in this zone. The Exclusion Zone of the newest generation of reactors and power plants is smaller than those of older plants. The next zone is the Sterilized Zone (B–C). Here, population growth is limited by administrative control. The outermost circle is the Emergency Planning Zone, which is constantly monitored for security and emergency planning purposes.

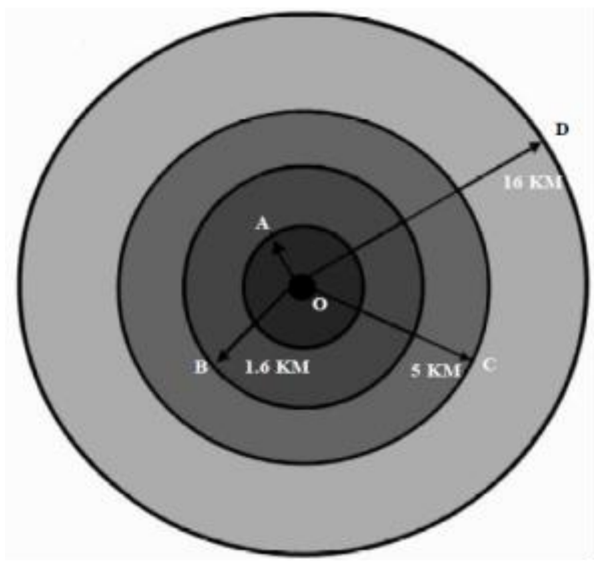

Figure 6. Perimeter Security Zoning System

According to the Indian government, for more sensitive parts of the facility, "a variety of surveillance, detection, delay, response and access control measures are in place in a graded manner over four layers."[141] Normally, access control is maintained over personnel by verifying identity cards. The "BARC has invented a phonetic numbering system with many novel mathematical

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[139] Government of India, Atomic Energy Regulatory Board, "Security of Radioactive Sources in Radiation Facilities," *AERB Safety Guide*, AERB/RF-RS/SG-1, March 2011. http://www.aerb.gov.in/AERBPortal/pages/English/t/publications/CODESGUIDES/SG-RF-RS-01.pdf

[140] Parliament of India, Lok Sabha, Unstarred Question No. 3505, Answered on January 2, 2019. http://loksabhaph.nic.in/Members/QResult16.aspx?qref=76986

[141] Government of India, Ministry of External Affairs, *Nuclear Security in India*, March 2014. https://www.mea.gov.in/in-focus-article.htm?23091/Nuclear+Security+in+India

features, permitting unique identification of people with only six digits, called the Phonetic Code".[142] The 'Need to Know' principle was adopted for information security relating to matters such as source location, specific security plans and measures, source utilization plans, and date and time of source transfer. The GCNEP, in collaboration with BARC and other agencies, provides training courses for concerned authorities regarding requirements, design, and evaluation of PPS.[143]

The CISF, a paramilitary force, oversees providing security to civilian nuclear facilities in the country. Each nuclear facility is guarded by a CISF team headed by a Commandant. According to an article published in *The Economic Times*, at many sites, "the CISF team is supplemented by a Special Task Force."[144] A Departmental Committee headed by an Inspector General of Police at the Secretariat oversees the physical security at the sites. The CISF team is also known to be trained with the ability to deploy specially-trained first responders in case of a chemical, biological, radiological and nuclear (CBRN) emergency. Many companies of the CISF with specialized training are deployed in various locations: the Ghaziabad unit caters to Delhi and other northern areas of the country; the Ranchi unit supports the eastern areas of India; Kota unit is assigned to India's western areas; and Chennai unit supports the southern part of the country. In its own training institute at the National Industrial Security Academy—located in Hyderabad, Andhra Pradesh—the CISF imparts skills to its members to deal with CBRN-related incidents. The CISF teams posted in charge of securing nuclear installation are also given facility-specific training by experts from the nuclear establishment itself.

The CISF is not in charge of all nuclear-related installations in the country. For example, as revealed in Rajya Sabha, the Heavy Water Plant in Baroda is guarded by departmental security personnel with armed police support under the command of Deputy Commissioner of Police, Special Branch, Baroda City. The Heavy Water Plant in Hazira is co-located with the Krishak Bharati Cooperative Ltd. (KRIBHCO) fertilizer plant and its security is managed by KRIBHCO security personnel, in addition to armed police personnel from the State Police. In another example, the Institute of Plasma Research at Gandhi Nagar employs private security personnel.[145] This suggests that depending on the severity or sensitivities involved in specific facilities, separate management strategy and required level of security is arranged respectively.

India's National Disaster Relief Force is trained to deal with nuclear disasters, if not security. Reports indicate, however, that the agency is not yet fully ready to deal with nuclear disasters. An *Indian Express* story had this to say:

> "In theory, there's back-up in place already. A nuclear emergency should set off what's called a level 3 response – involving the country's defence, paramilitary, police, and government agencies all the way from the Centre to the taluka. The National Disaster Management Agency had prepared a structured document, providing precise directions on rescue, decontamination, and evacuation, to be administered in real-time by control rooms at the Ministry of Home Affairs in New

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142 D. N. Srivastava, "Hi-Tech Computerized Security Management," *Nuclear India*, Vol. 34, No.3–4, Sep–Oct 2000, DAE, Government of India. http://www.dae.gov.in/node/171

143 Global Centre for Nuclear Energy Partnership, "Programs." http://www.gcnep.gov.in/programs/programs.html

144 Dipanjan Roy Chaudhury, "Global Body Gives India Poor Rating on Nuclear Safety, May Stall Entry into Nuclear Supplier Group," *The Economic Times*, May 1, 2015. https://economictimes.indiatimes.com/news/politics-and-nation/global-body-gives-india-poor-rating-on-nuclear-safety-may-stall-entry-into-nuclear-supplier-group/articleshow/47117247.cms?from=mdr

145 Rajya Sabha, Unstarred Question No. 2175, "Security at Units of Atomic Energy," answered on December 13, 2012. http://dae.nic.in/writereaddata/rsus2175.pdf

> Delhi and in the states. The reality is that Maharashtra doesn't have a set of operating procedures in place, which would govern all organisations in a crisis."[146]

However, given the dispersed and individualized approach to handling security at various nuclear facilities, it would be prudent to consider (1) a strategy of a unified or centralized security arrangement in all nuclear related installations for better coordination, security planning and implementation; and/or (2) develop a separate security force similar to that of the United Kingdom's Civil Nuclear Constabulary that can be tasked to secure nuclear facilities only.[147] The CISF must be commended for its unblemished record of securing nuclear installations in the country so far; but its mandate is vast for it is entrusted with safeguarding many other critical national infrastructures in the country simultaneously. Though sporadic, incidents of misconduct by CISF personnel have been reported.[148] Moreover, the CISF officials trained to safeguard nuclear installations are rotated among the nuclear installations and are not kept in one place for more than a certain number of years as a standard operating procedure for security forces. They are also shifted for other assignment in other sectors. Given India's ambitious push for nuclear energy expansion in recent decades, it might be prudent to adopt either of the methods suggested above.

In 2013, the Ministry of Atomic Energy responded to a question about a security threat at the Kudankulam Power Plant with the following information, ". . . Department of Atomic Energy installations and its residential colonies continue to remain potential targets of outfits and elements inimical to the interest of India. . . .anonymous letters were received at KKNPP threatening to bomb blast at plant and kidnap senior officials".[149] Reportedly, the 2008 Mumbai terror attacks planner, David Coleman Headley, surveyed the BARC complex for a possible terror strike.[150] Headlines like "BARC Security Breached 25 Times in Two Years" (IBN Live March 2012) as a result of (according to the IBN news report) "a lack of unified command and control, as security is handled by both AEC and CISF"[151] has been refuted vehemently by BARC authorities. A 2012 BARC press statement reads: "[N]ot a single intrusion took place within the security perimeter of BARC during last two years."[152] The 2012 BARC press release acknowledges that ". . . seven unauthorized loiters were apprehended outside the security perimeter due to integrated security infrastructure in place, along with the highly alert security personnel of CISF and DAE. . . ."[153]

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[146] Smita Nair, "Nuclear Disaster: Control Rooms with No Bosses, Hotline Turned Cold," *The Indian Express*, October 21, 2014. http://indianexpress.com/article/india/india-others/nuclear-disaster-control-rooms-with-no-bosses-htline-turned-cold/99/

[147] Rajeswari Pillai Rajagopalan, *Nuclear Security in India*, Observers Research Foundation, New Delhi, pp. 78–79, 84. 2015.

[148] "CISF Man Kills 3 Colleagues at Kalpakkam Atomic Plant," *The Times of India*, October 9, 2014. https://timesofindia.indiatimes.com/india/CISF-man-kills-3-colleagues-at-Kalpakkam-atomic-plant/articleshow/44729806.cms

[149] Parliament of India, Lok Sabha, Unstarred Question No. 2626, "Security Threat to Kudankulam Power Plant," March 13, 2013. http://loksabhaph.nic.in/Questions/QResult15.aspx?qref=138087&lsno=15

[150] Shoaib Ahmed, "Mumbai: BARC Security Breached 25 Times in Two Years," *CNN-IBNLive*, March 28, 2012. http://ibnlive.in.com/news/mumbai-barc-security-breached-25-times-in-2-years/243563-3.html

[151] Ibid.

[152] Bhabha Atomic Research Centre, "Press Release on the Security Related Concerns Expressed in the Media," Press statement released on April 3, 2012. http://www.barc.gov.in/press/2012/index2012.html

[153] Ibid.

4.4.3. Personnel Reliability

India's nuclear establishment follows a personnel reliability program designed with several lines of inquiry. Generally, a background check of the employee is conducted to verify identity, credit history, criminal history, reputation, and character. A series of psychological and medical screenings are used to evaluate the mental health and stability of the individual, taking into consideration aspects such as depression, schizophrenia, epilepsy, high/low blood pressure, and other disorders. To motivate and ensure a fair working environment, the government of India has stated that employees "are provided with excellent living conditions and career opportunities. The Scientific and Technical promotions in the Department are governed by the Merit Promotion Scheme and are not vacancy based. Compulsory health care facilities are provided covering all disciplines including mental help, social welfare services, counseling, and psychiatry. This covers both employees and their families. Cultural and recreational activities are also conducted regularly."[154]

Additionally, a detailed interview to verify background information and elucidate other potential concerns is conducted at the time of employment, or when any sensitive task is being assigned. According to the NPCIL's 2018-19 annual report, one of the 'Core Values' of the organization is "To develop personnel at all levels through an appropriate Human Resources Development (HRD) programme in the organisation with a view to further improve their skills and performance consistent with the high technology."[155] In addition, the AERB has developed a formal code of professional ethical values for all employees.[156] In order to ensure all activities in nuclear and radiation facilities in India are conducted in compliance with the Atomic Energy Act of 1962, the officials shall be guided by the principle to to maintain a high level of professional competence, maintain a high level of honesty and integrity, and be principled and consistent in application of regulations, among other guidelines. All employees of the AERB must accept a statement of responsibility to uphold the highest standards of professional conduct in the performance of professional duties.[157]

Similarly, the NPCIL, which operates the country's nuclear power plants, has mandated a Code of Ethics and Conduct requiring "commitment for ethical professional conduct from every director and senior employee."[158] The code, formulated in the form of statements of personal commitment, bestows responsibilities on concerned personnel for the design, construction, operation, and maintenance of nuclear power projects. The code asks employees to maintain confidentiality of information, strive to achieve the highest quality, mutual trust, and transparency and, avoid conflicts of personal interest with the interest of the company at large. The other public sector undertaking, Bharatiya Nabhikiya Vidyut Nigam Ltd. (BHAVINI), has its own code of business conduct and ethics for board members and senior management along with a Fraud Prevention Policy to provide a system for prevention/detection/reporting of any fraud that is detected. To promptly identify and

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[154] Parliament of India, Lok Sabha, Question No. 6416, "Suicide Among Scientists," Answered May 5, 2010. http://www.dae.gov.in/node/459

[155] Nuclear Power Corporation of India Ltd, *32nd Annual Report 2018-19*, https://www.npcil.nic.in/WriteReadData/userfiles/file/NPCIL_Annual_Report_2018_19_English_16dec2019.pdf.

[156] Government of India, Atomic Energy Regulatory Board, Code of Ethics. https://aerb.gov.in/english/about-us/code-of-ethics

[157] Ibid, p. 5.

[158] Nuclear Power Corporation of India Ltd., *Code of Ethics and Conduct*. https://www.npcil.nic.in/content/330_1_CodeofEthicsandConduct.aspx

investigate allegations of corruption or malpractice, a vigilance unit headed by a Chief Vigilance Officer is stationed in all DAE units.[159]

The NPCIL has also instituted a Vigilance Directorate with the objective "to eliminate or minimize factors which provide opportunity for corruption or malpractices through in-depth examination . . . [and] regular inspection and surprise visits," ensuring prompt observance of proper conduct and ethics relating to integrity.[160] According to the corporation, it maintains surveillance on employees who have access to sensitive parts of the plants and performs regular and surprise inspections to detect possible misconduct.[161]

Occasional incidents of malpractice in different departments of the establishment have been reported. According to *The Times of India*, in November 2009, some employees of a maintenance unit of the Kaiga plant were treated "for increased level of tritium after they drank water from a cooler in the operating area".[162] In a clarification, India's Minister for Science and Technology, Prithviraj Chavan, said an insider at the plant was suspected of spiking the cooler with "heavy water."[163] In addition, questions have been raised in the Parliament regarding suicides and mysterious deaths of personnel.[164] Sekhar Basu, former Director of BARC, argued in 2014 that "[t]he number of deaths due to suicide is less than 100 (69 to be precise) over a period of 20 years and over 60,000 employees work at the DAE."[165] According to revelations gained through examining Right to Information (RTI) responses, between January 1, 2008, and October 1, 2016, around 70 people, including scientists and engineers working with the various establishments and research laboratories of the DAE, have died unnaturally. Most deaths (38) were of officials from BARC due to accidents at various locations. Other deaths include 15 employees of Atomic Minerals Directorate for Exploration and Research; 12 employees of Indira Gandhi Centre for Atomic Research; and 5 employees of various other organizations belonging to the DAE.[166] The official view is that none of these unnatural deaths are connected to radiation exposure, working conditions, or official activities. Rather, the Department of Atomic Energy claims safety and security measures to prevent casualties are in place at all nuclear power plants, and employees are provided with "excellent living conditions and career opportunities;" compulsory health care facilities are provided including social welfare services, mental help, counseling, and psychiatry.[167] Undoubtedly the PRP in Indian nuclear-related agencies is well-established but for private operators/suppliers, who will be increasingly involved in India's nuclear energy expansion drive, the issue will be tricky.

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159 Government of India, Department of Atomic Energy, *Annual Report 2016-17*, p. 214. http://www.dae.gov.in/node/855

160 Nuclear Power Corporation of India Ltd, "Vigilance." https://www.npcil.nic.in/content/256_1_Vigilance.aspx

161 Nuclear Power Corporation of India Ltd, "Director's Report," *Annual Report 2004-2005*, p. 17.

162 "Union Minister Confirms Nuclear Sabotage," *The Times of India*, November 29, 2009.

163 "Water Cooler at Indian Nuclear Plant Contaminated," *Voice of America*, November 29, 2009. https://www.voanews.com/archive/water-cooler-indian-nuclear-plant-contaminated

164 Lok Sabha Unstarred Question No. 3362, "Deaths of Scientists in BARC," 12 February 2014. http://dae.nic.in/writereaddata/parl/budget2014/lsus3362.pdf; Lok Sabha Unstarred Question No. 324, 23 February 2011. http://dae.nic.in/writereaddata/324_lsus230211.pdf.

165 Pradipti Jayaram, "Counting Suicides in India's Nuclear Family," *The Hindu Business Line*, October 13, 2014. https://www.thehindubusinessline.com/news/variety/Counting-suicides-in-India%E2%80%99s-nuclear-family/article20886209.ece

166 Abhinandan Mishra, "Atomic Energy Department Saw 70 Unnatural Deaths in Eight Years," *The Sunday Guardian*, December 4, 2016. https://www.sundayguardianlive.com/investigation/7559-atomic-energy-department-saw-70-unnatural-deaths-eight-years

167 Parliament of India, Lok Sabha, Question No. 6416, "Suicide Among Scientists," Answered May 5, 2010. http://www.dae.gov.in/node/459

4.4.4. Material Protection Control and Accounting

India has devised and put in place a comprehensive material protection control and accounting program. According to a seminar presentation by K. Raghuraman from the DAE, India's system comprises three basic elements: (1) the legislative and regulatory framework; (2) an integrated physical protection program for facilities and materials; and (3) a comprehensive Nuclear Material Accounting and Control (NUMAC) system.[168] The goals of NUMAC are to identify nuclear material by type, nature, and amount; to implement accounting and control mechanisms; to ensure measurement capabilities and statistical analysis of reported data as efficient; to oversee auditing practices and implement inspection and verification practices; and to ensure the compliance of constructive measurements, periodic inspection, verification and auditing, and documentation of inventory changes and discrepancies thereof. [169] While all facilities are covered by a multi-layered security system, facility-specific NUMAC arrangements are in place under an Officer in Charge. Raghuraman has further elaborated that the Inventory Information and Control and Data Management Section and a control laboratory compile and preserve the information. The activities of all NUMAC facilities are coordinated through a central NUMAC group at the DAE. At the top, the Senior Coordination Committee reviews NUMAC reports to initiate actions, if needed.[170]

Several layers of security are in place to physically protect nuclear material stores. In the inner layer around the nuclear material, it is believed that the 'two-man rule' applies to opening locks. The "material is guarded by using indigenously developed electronic seals for storage containers and portals for detection of nuclear material in personnel monitoring."[171] A Nuclear Control and Planning Wing was created in 2013 in the DAE to take "the lead on international cooperation on nuclear security" by integrating DAE's safeguards, export controls, and nuclear security related activities.[172]

4.4.5. Transportation Security

Given its large number of nuclear installations, expanding infrastructure, and increasing use of radioactive material in various sectors, India must commit to the safety and security of nuclear material in transport. More than 100,000 packages are being transported annually in India with materials varying in radioactivity from few thousand becquerel to over 10^{15} becquerel.[173] In 2008, the AERB issued a safety guide on security levels of radioactive material during transport (AERB/NRF-TS/SG-10) that prescribes the requirements for ensuring safety in the movement of radioactive

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[168] Based on K. Raghuraman's presentation during an international workshop on "Protection, Control, and Accounting of Nuclear Materials: International Challenges and National Programs" at the National Academy of Sciences, Washington, DC. Also refer to Christopher Eldridge, "Domestic MPC&A Program," *Protection Control and Accounting of Nuclear Materials*, National Academy of Sciences, Washington, D.C., pp. 39–40. https://www.nap.edu/read/11343/chapter/10

[169] Ibid, p. 40.

[170] K. Raghuraman, "Domestic MPC&A Programs," *Protection Control and Accounting of Nuclear Materials*, National Academy of Sciences, Washington, D.C., p. 40. https://www.nap.edu/read/11343/chapter/10#40

[171] "Physical Security at Civilian Nuclear Facilities," in the National Academy of Sciences compiled *India-United States Cooperation on Global Security: Summary of a Workshop on Technical Aspects of Civilian Nuclear Materials Security,* Washington, D.C., The National Academies Press, 2013, p. 63. https://doi.org/10.17226/18412

[172] "National Progress Report: India," *National Progress Reports*, 2014 Nuclear Security Summit, The Hague, Netherlands, March 24–25, 2014. http://projects.iq.harvard.edu/files/nuclearmatters/files/national_progress_report_india.pdf

[173] Government of India, Atomic Energy Regulatory Board, "Transport of Radioactive Material." https://www.aerb.gov.in/english/regulatory-facilities/transport-of-ram

material through public domain.[174] In compliance with IAEA stipulations, the AERB revised its code on the Safe Transport of Radioactive Material—AERB/NRF-TS/SC-1 (Rev.1)—in 2016, which "prescribes the classification, design and test requirements for radioactive material for packaging . . . transport and administrative requirements for transportation of radioactive material in the country." [175]

Specific requirements are given for packaging of the material to be transported. As per the AERB explanation, a graded approach is used in the selection of packaging depending upon the fissile characteristics of the material and risk involved. The types of packages used for the transport of radioactive materials are Excepted, Industrial, Type 'A', Type 'B(U)', Type 'B(M)' and Type 'C'. Type 'A' packages are used for the transport of moderate activity radioactive material such as nucleonic gauge sources, brachytherapy sources, nuclear medicine sources, etc. Type B(U) / B(M) packages are meant for transport of high activity radioactive material; Type C packages are used for transport of very high radioactivity by air. The consignor has primary responsibility for ensuring compliance with the government's regulations.[176]

Similarly, security levels are specified for different materials (category 1 to 5) in transit, depending upon their degree of fissile characteristics and danger involved. This includes, amongst others, prior approval for the shipment, special vehicles, security locks, appropriate training of personnel involved, additional security and escort by armed guards, secure communication support, and an on-line tracking system.[177] Generally, nuclear materials are transported with heavy security cover and patrolling provided by multiple agencies. According to information presented in a 2013 global security workshop, while the nuclear material/technology is in transit, real-time tracking of secure vehicle transportation using geostationary satellite is undertaken along with "local Global System for Mobile Communications or Code Division Multiple Access (CDMA) mobile communication network" from a central monitoring station.[178] As per the guidelines, there will be no predetermined or set route of transportation; altering routes is an essential requirement for transportation of radiological materials.[179]

Less security cover is provided during transportation of such materials as cobalt, strontium, and cesium, or equipment used in smaller research institutes, as they are of low radioactivity and small quantity. Keeping in mind the unforeseen contingencies that may arise during transportation of sensitive materials, the government of India has instituted an Inter-Ministerial Working Group (consisting of representatives of the Department of Civil Aviation, Ministry of Surface Transport, Railway Board, and the DAE) to oversee emergency response procedures during transport of radioactive materials.[180] As per *the Air Safety Circular No. 2 of 1989*, "all airlines (scheduled/non-

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[174] Government of India, Atomic Energy Regulatory Board, "Security of Radioactive Material During Transport," AERB Safety Guide No. AERB/NRF-TS/SG-10, 2008. https://aerb.gov.in/english/publications/codes-guides
[175] Government of India, Atomic Energy Regulatory Board, "Safe Transport of Radioactive Material," AERB Safety Code No. AERB/NRF-TS/SC-1 (Rev.1), 2016. https://aerb.gov.in/english/publications/codes-guides
[176] Government of India, Atomic Energy Regulatory Board, "Transport of Radioactive Material." See footnote 199 for link.
[177] Government of India, Atomic Energy Regulatory Board, "Security of Radioactive Material During Transport," AERB Safety Guide No. AERB/NRF-TS/SG-10, 2008, pp. 13-16. See footnote 200 for link.
[178] Ranajit Kumar, "Technologies and Physical Security of Nuclear Materials: An Indian Perspective," in the National Academy of Sciences compiled *India-United States Cooperation on Global Security: Summary of a Workshop on Technical Aspects of Civilian Nuclear Materials Security (2013)*, Washington, D.C.: The National Academies Press, 2013, p. 63.
[179] Rajeswari Pillai Rajagopalan, "India and the Nuclear Security Summit," April 27, 2016, p. 29. https://www.orfonline.org/research/india-and-the-nuclear-security-summit/
[180] Office of the Director General of Civil Aviation, Air Safety Directorate, *Air Safety Circular No. 2 of 1989*, January 13, 1989. http://dgca.nic.in/circular/asc02-89.htm

scheduled) operating in India and all airport management authorities should ensure that all their concerned officials are made fully familiar of the emergency response procedure enclosed."[181]

4.4.6. Air and Water Front Defense

Within a month after the 9/11 terror attacks, New Delhi promulgated no-fly zone restrictions around nuclear power plants. Reportedly, flights over BARC were also banned because of fears that planes flown by countries hostile towards India could perhaps crash into the reactors in suicide missions.[182] Requisition for additional anti-aircraft guns was made for deployment to the Narora Atomic Power Plant in Rajasthan and for two atomic power plants in southern India.[183] It would be fair to assume that these national critical infrastructures are adequately protected by anti-aircraft defenses and other air defense systems.

Taking no chances with its security following the Mumbai terror attacks (November 26, 2011), security arrangements around India's key nuclear installations were reviewed. As a step in this direction, the Director General of Civil Aviation "declared a no-fly zone around the Kalpakkam nuclear plant" in Tamil Nadu,[184] BARC, and the Tarapur Atomic Power Station in Mumbai.[185]

In a meeting held on April 27, 2011, chaired by the then CISF Director-General N.R. Das and attended by top officials of 14 atomic energy plants, the DAE and CISF reviewed the security arrangements of major nuclear power plants, considering the constant threat to India's sensitive installations.[186] In the meeting it was decided to strengthen the waterfront security of all nuclear installations located near water bodies and fortify these areas with the help of additional security personnel and deployment of security devices. Enhanced security would be provided by coordination among local police, the Indian Army and Navy, anti-terrorism squad (ATS) crime branches, and secret agencies. To meet the threat that may arise from the waterfront, the Indian Coast Guard reportedly deploys additional boats off the coast of Bombay to guard BARC. On threat alerts, high-speed Coast Guard ships, high-intensity cameras, and helicopters are deployed for patrolling and air cover, respectively. They are equipped with the necessary capability to neutralize any missile attack along the coast.[187]

4.4.7. Security of Radiological Materials

Arguably, physical protection at the sites where radiological sources, materials, devices, and instruments are used in India (e.g., hospitals, research facilities, oil and gas exploration industry, road

[181] Ibid.

[182] Srinivas Laxman and Chinmayi Shalya, "Ban Flight of Civilian Planes over BARC: Experts," *The Times of India*, December 4, 2008. https://timesofindia.indiatimes.com/city/mumbai/Ban-flight-of-civilian-planes-over-BARC-Experts/articleshow/3789730.cms

[183] "Indian Atomic Energy Body Wants 'No Fly Zones' Over Nuke Facilities," *Deutsche Presse-Agentur*, February 5, 2002, in Lexis-Nexis Academic Universe, February 13, 2005. http://www.lexis-nexis.com

[184] Brahmand News Service, "India Declares Kalpakkam Nuclear Plant No-Fly Zone," *Brahmand.com: Defence & Aerospace News*, December 17, 2008. http://www.brahmand.com/news/India-declares-Kalpakkam-nuclear-plant-no-fly-zone/821/1/12.html; and Vinay Kumar, "Kalpakkam Nuclear Plant No-Fly Zone," *The Hindu*, December 17, 2008, https://www.loc.gov/law/foreign-news/article/india-no-fly-zone-over-nuclear-plant/

[185] Srinivas Laxman and Chinmayi Shalya, "Ban Flight of Civilian Planes over BARC: Experts," *The Times of India*, December 4, 2008. See footnote 208 for link.

[186] "DAE, CISF Review Security of Nuclear Power Plants," *The Times of India*, April 29, 2011. https://timesofindia.indiatimes.com/india/DAE-CISF-review-security-of-nuclear-power-plants/articleshow/8122343.cms

[187] Rajnish Sharma and Shailesh Gaikwad, "Fears of a Missile Attack on BARC," *Hindustan Times*, August 13, 2006. https://www.hindustantimes.com/india/fears-of-a-missile-attack-on-barc/story-cXu2Zq4EiRxMBBFrdUWT1K.html

construction industry, and steel manufacture) is lacking. In a 2004 article on nuclear threats in India, Rajesh Basrur and Friedrich Steinhäusler write that physical security "is rather lax, at best comparable to the protection provided at a jeweler shop (i.e., not a real logistical problem for a trained team of adversaries.)"[188]

As mentioned earlier, the Mayapuri incident was a wake-up call for the Indian nuclear establishment. The scrap market was not equipped with radiation detection devices, and the scrap workers had no radiation-related awareness. Even the authorities in charge of the university laboratory were unaware of the radiological material inside the unused gamma-irradiator. The AERB had no inventory of radioactive materials sourced from abroad prior to its own existence. Before the AERB (set up in 1983), the Directorate of Radiation Protection (DRP) was responsible for the radiation protection program, including radiation surveillance in hospitals, industries, and research institutes. This suggests a lack of coordination between the DRP and AERB after the DRP was established.[189] Another such preventable incident involved the misplacement of a power source containing plutonium-238, an alpha emitter, in sealed conditions installed at Nanda Devi (Indian side of Himalayas), which could not be traced in spite of several attempts.[190] Many gaps seem to exist at each level, starting from the suppliers' responsibility to the users' obligation, and finally, lack of public awareness.

Most alarming are reports of radioactive material smuggling in and around India. In 2016, the DAE, Intelligence Bureau, and Rajasthan Police's ATS reportedly uncovered a mineral smuggling racket that involved exports of beryl, an atomic mineral ore of beryllium, to China.[191] Six people were arrested and several tonnes of beryl were recovered after the joint operation. As per the report, prior to this operation, a 20-tonne consignment of beryl is believed to have been smuggled to Hong Kong from Kandla Port in Gujarat.[192] Similarly, in 2001 uranium smuggled from the Jaduguda mines was confiscated in Balurghat in northern West Bengal. According to a report published, the uranium was "planned to be smuggled across the Bangladeshi border".[193] Five people were arrested in Meghalaya for allegedly trying to smuggle uranium on September 10, 2008.[194] Many other unverified instances of smuggling have been reported. These include:

- Uranium-235 weapons-grade material recovered from criminals in Tamil Nadu in 1998; the theft of more than 8 kg of natural uranium from the Indira Gandhi Centre for Atomic Research in Chennai (later seized by the Central Bureau of Investigation in 1999); the recovery of 26 kg of uranium from illicit traffickers in Hyderabad in 2000; and a gamma radiography camera containing iridium-192 stolen during transportation in Assam in July 2002;[195]

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188 Rajesh M Basrur and Friedrich Steinhäusler, "Nuclear and Radiological Terrorism Threats for India: Risk Potential and Countermeasures," *The Journal of Physical Security*, Vol. 1, Issue 1, 2004, p. 5.
189 Sitakanta Mishra, "Radiation Safety: How Prepared Are We?" *National Defence & Aerospace Power*, Centre for Air Power Studies, New Delhi, No. 25/10, May 15, 2010.
190 Parliament of India, Lok Sabha, "Missing of Nuclear Device" Unstarred Question No. 2194, Answered on March 10, 2010. http://www.dae.gov.in/node/459
191 Anil Sasi, "Atomic Material Smuggling Racket Busted, Rajasthan ATS Arrests 6," *The Indian Express*, March 21, 2016.
192 Ibid.
193 "Police Seize Uranium from West Bengal Villager", https://www.nti.org/analysis/articles/police-seize-uranium-west-bengal-villager/
194 "Five Arrested for Alleged 'Uranium' Smuggling, Say Police," *Space War: Your World at War*, September 11, 2008. http://www.spacewar.com/reports/Five_arrested_for_alleged_uranium_smuggling_say_police_999.html
195 Rajeswari Pillai Rajagopalan, et al., *Chemical, Biological and Radiological Materials: An Analysis of Security Risks and Terrorist Threats to India*, a joint report by the Observer Research Foundation and Royal Services Institution, 2012.

- An industrial ionising radiation-gauging device containing about 9.25 GBq cesium-137 source, used in a coal washery, ". . . was found to be missing from the premises on November 16, 2006";[196]
- Seizure of around 4 kg of low-quality uranium after the Bihar police arrested a group of smugglers from the Nepal border in 2008;[197] and
- Fifteen disused cobalt-60 isotopes stolen from the SAIL Durgapur plant in January 2011.[198]

Increasing incidents of uranium ore smuggling in the Nepal-Bihar-Jharkhand-West Bengal conduit have been reported that raise the issue of security of uranium mining. Information on the security arrangement in uranium mines and mining activities is not publicly available. Moreover, smuggling of monazite sands (a beach sand mineral containing thorium) from the beaches in the states of Tamil Nadu, Kerala, and Odisha are reported. Even though DAE has not given license to any private entity except the state-run Indian Rare Earth Ltd. to produce, process, and export monazite, a mining cartel led by a Tirunelveli firm has allegedly mined and quietly exported the material.[199] Another report reveals that around 2.1 million tonnes of monazite, equivalent to 195,300 tonnes of thorium at 9.3 percent recovery, disappeared from the shores of India.[200] In an answer to a question on mining of monazite in the Lok Sabha, then Minister of State for Personnel, Public Grievances & Pensions and Prime Minister's Office, V. Narayansamy, replied that minerals like ilmenite, rutile, leucoxene, garnet, sillimanite, and zircon are free of monazite and "delisted from the prescribed substances list" and, therefore, private companies are allowed to separate and export these materials from beach sands. He goes on to say: "However, licence under the Atomic Energy Act is still required for handling / [e]xport of monazite and [t]horium, which are prescribed substances. This Department has not given any licences for export of beach sand as such.[201]

Chances of such incidents are hardly surprising as South Asia is situated between two well-established drug trafficking routes, the Golden Crescent and Golden Triangle. As noted in a 2012 study on security risks and terrorist threats to India, these incidents indicate that "while elaborate security structures have been put in place to prevent radioactive material falling into the hands of malicious actors, thus far it has not proved to be completely foolproof."[202]

Conscious of the threat, Indian authorities have tried to address the existing loopholes through policies and technological solutions. To ensure incidents like the one at Mayapuri are not repeated, the University Grant Commission (UGC), the national body that manages higher education in India, has issued comprehensive guidelines on the use of radioactive material by universities and colleges

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http://www.observerindia.com/cms/export/orfonline/documents/ORF-RUSI.pdf; and Jennifer Cole, "An Explosion of Demand", *CBRNe WORLD*, August 2012.

196 Government of India, Atomic Energy Regulatory Board, "Safety Surveillance of Radiation Facilities," *AERB Annual Report, 2006-2007*, p. 29. https://aerb.gov.in/english/annual-report-archives

197 "India Police Seize 8 lbs of Uranium from Smugglers," *Reuters*, February 19, 2008. http://www.reuters.com/article/worldNews/idUSB65928720080219?feedType=RSS&feedName=worldNews

198 "15 Disused Cobalt-60 Isotopes Stolen from SAIL in Jan," *The Economic Times*, March 14, 2011.

199 "How India Lost Thorium as Govt Bungled," *The Free Press Journal*, October 5, 2012. http://freepressjournal.in/how-india-lost-thorium-as-govt-bungled/

200 Sam Rajappa, "The Great Thorium Robbery," *The Statesman*, September 2, 2012. Available at: https://groups.google.com/forum/#!topic/poovulagu/8RHO2YZzcBw

201 Parliament of India, Lok Sabha, "Mining of Monazite," Unstarred Question No. 1531, Answered on November 30, 2011. http://164.100.47.194/Loksabha/Questions/QResult15.aspx?qref=112872&lsno=15

202 Rajeswari Pillai Rajagopalan, et al., *Chemical, Biological and Radiological Materials: An Analysis of Security Risks and Terrorist Threats to India*, a joint report by the Observer Research Foundation and Royal Services Institution, 2012, p. 15.

across the country.[203] BARC also has prepared a comprehensive inventory of all radioactive materials imported, used, and disposed in the country.

In 2011, India's ministry of shipping ordered the installation of radiation monitor portals in all major ports in the country.[204] Monitoring devices have been installed in the major seaports of the Jawaharlal Nehru Port Trust (JNPT, Navi Mumbai), Mumbai Port, Kandla, Goa, New Mangalore, Cochin, Tuticorin, Ennore, Chennai, Visakhapatnam, Paradip, and Kolkata. According to a 2007 study, only the JNPT is compliant with the Container Security Initiative and equipped with "automated container screening and information exchange" provisions to intercept the movement of radioactive materials.[205] This study is of the view that India should consider equipping its other major seaports with technology outlined in the Container Security Initiative.

Mobile radiation detection systems are being used across India to support radiological emergency preparedness. In 2011, the Union Home Ministry sanctioned setting up nearly 1,000 mobile radiation detection systems in police stations of 50 major Indian cities for detecting radiation. In October 2019, the National Disaster Management Authority (NDMA) has decided to deploy more such surveillance vehicles across the country to take necessary action in case of any danger.[206] The cities that have been identified in the first phase of monitoring include Delhi, Mumbai, Kolkata, Chennai, Bangalore, Hyderabad, Ahmedabad, Pune, Lucknow, Jaipur, Thiruvananthapuram, Patna, Ranchi, Bhopal, Agra, Kanpur, Indore, Bhubaneswar, and Chandigarh.[207]

Indian scientists have developed two types of indigenous radiation detection systems using plastic scintillators, a portal monitor for pedestrians and a camouflaged limb/pole monitor.[208] These have been calibrated and installed at a few facilities to detect orphan sources and unauthorized movement or illicit trafficking of radioactive materials. An instrument named the Fluorimeter has been developed by a DAE unit to measure traces of uranium in water.[209] At India's major transit points, border crossings, and airports, radiation monitoring devices have been installed to monitor the unauthorized movement of radioactive materials.[210] Devices have been positioned in 14 major

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203 University Grants Commission, "UGC Guidelines for Universities, Research Institutes and Colleges for Procurement, Storage, Usage and Disposal of Radioactive and other Hazardous Material/ Chemicals," January 2011. https://www.ugc.ac.in/page/XI-Plan-Guidelines.aspx

204 "India to Install Radiation Monitors for Steel Scrap Import at All Major Port," *Steel News*, published on SteelGuru.com, December 16, 2011. http://www.steelguru.com/indian_news/India_to_install_radiation_monitors_for_steel_scrap_import_at_all_major_port/241105.html

205 Gurpreet S Khurana, "India and the Container Security Initiative," *IDSA Comment*, published on IDSA: the Institute for Defence Studies and Analyses, July 17, 2007. https://idsa.in/idsastrategiccomments/IndiaandtheContainerSecurityInitiative_GSKhurana_170707

206 Harish V Nair, "NDMA to deploy 1000 vehicles to detect radioactive radiation leakage", https://www.indiatoday.in/india/story/1000-ndma-vehicles-to-detect-radioactive-emissions-266962-2015-10-08

207 Vishwa Mohan, "50 Cities to Get Mobile Kit to Trace Radiation," *The Times of India*, October 6, 2011. https://timesofindia.indiatimes.com/india/50-cities-to-get-mobile-kit-to-trace-radiation/articleshow/10260768.cms

208 M. Harikumar, M. Thakur Vaishali, Amit Kumar Verma, G. Krishnamachari, and D. N. Sharma, "Detection of Unauthorized Movement of Radioactive Sources in the Public Domain for Regaining Control on Orphan Sources – Systems and Feasibility," International Atomic Energy Agency, Report IAEA-CN-134, 2005. http://www.unece.org/fileadmin/DAM/trans/radiation/docs/India.pdf

209 Press Trust of India, "DAE Unit Develops Device to Measure Uranium Traces in Water," *Business Standard*, March 22, 2018. https://www.business-standard.com/article/pti-stories/dae-unit-develops-device-to-measure-uranium-traces-in-water-118032200801_1.html

210 Y. Mallikarjun, "Seaports, Airports to Get Radiation Detection Equipment," *The Hindu*, May 3, 2012. Updated July 11, 2016. https://www.thehindu.com/news/national/seaports-airports-to-get-radiation-detection-equipment/article3381141.ece

airports, including Delhi, Mumbai, Chennai, Kolkata, and Amritsar. The remaining airports will be covered in a phased approach. Similarly, in the first phase, devices have been installed at 13 integrated border check posts including the check posts at Wagah-Attari and on either side of the India-Nepal border. Police and border security forces have been given the necessary training to identify and respond if such an event is noticed. In 2004, India's Border Security Force formed a battalion with special skills in countering nuclear, biological, and chemical threats. As described in a 2015 article, with the aim to tackle danger arising out of the possibility of terrorists using WMDs, "the DRDO has developed a mobile truck mounted laboratory to screen troops in the field from the after effects of radiation and initiate remedial measures. The chamber, termed as Mobile Whole Body Counter (MWBC) will do away with the necessity and the logistic impediment of evacuating soldiers from operational areas to rear echelons."[211]

Above all, India has established an inter-ministerial Counter Nuclear Smuggling Team to devise a coordinated multi-agency institutional mechanism to strengthen the national detection architecture for nuclear and radioactive material and deal with the threat of individuals or groups of individuals acquiring nuclear or radiological material for malicious purposes.[212] The team studies and suggests effective and coordinated response to the evolving threat of smuggling.

4.4.8. Information and Cyber Security

The extensive use of network-based systems and information technology in critical infrastructure has given rise to concerns of potential attacks from external sources to gain access. It is alleged that India currently has neither a strong cyber law nor effective cyber security capabilities. Government websites and emails have been frequently hacked. According to media reports a few years ago, computers at the Rare Materials Plant, Rattehalli, were possibly infected by malware.[213]

The cyberattack on the Kudankulam Nuclear Power Plant (KKNPP) in Tamil Nadu in September 2019 hints that upping the ante on cyber security of Indian nuclear infrastructure is the need of the hour. In a press release, the NPCIL revealed that the maleware infected computer was part of plant's administrative network which "is isolated from the critical internal network"… the investigation also confirms that the plant systems are not affected".[214] Reportedly, Kaspersky farm identified the malware as

MAJOR RESPONSIBILITIES OF CISAG

- Provide guidance and issue guidelines to all Units and its CISO
- Ensure all Units have a formal IT security policy in place and oversee their implementation
- Prescribe audit procedures and organize quarterly IT security audits or major/critical DAE Units
- Conduct information security audits and cross audits
- Act as nodal point of DAE for interacting with CERT-In/NCIIPC/MHA, etc.

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211 Vijay Mohan, "DRDO Develops Mobile Lab to Screen Troops in Nuclear Scenario," *The Tribune*, January 6, 2015. https://www.tribuneindia.com/news/nation/drdo-develops-mobile-lab-to-screen-troops-in-nuclear-scenario/26753.html

212 Parliament of India, Lok Sabha, "Nuclear Threat Initiative," Starred Question No.251, Answered on May 11, 2016. http://164.100.47.194/Loksabha/Questions/QResult15.aspx?qref=35170&lsno=16

213 S. Raghotham, "Cyber Attack on Key N-Facility in Mysore?" *The Asian Age*, November 2, 2011.

214 NPCIL, Press Release, October 30, 2019, https://npcil.nic.in/writereaddata/Orders/201910301237346960171News_30102019_01.pdf

Dtrack, which was previously linked to North Korea. The incident could act as a catalyst in strengthening the cyber security systems in Indian nuclear plants.

Situated in an unstable neighborhood with non-state actors, India's nuclear infrastructure is vulnerable to cyber espionage or sabotage. One wonders if the Indian technocrats are fully prepared to mitigate a Stuxnet-type or a fullfledged Dtrack-type maleware attack on all its nuclear installations.

Not much information was available in the public domain on India's cyber and information security arrangement protecting its nuclear installations. With increased global concerns on cyber threats, information has started to emerge providing a sense that India has put in place a well-defined cyber and information security arrangement that includes instrument and control security and facility network security. A Task Force for Instrumentation and Control Security was created along with a Cyber Security Crisis Management and Incident Response Plan. Digital control over physical installations is ensured through the Critical Digital Assets Identification Process. On the other hand, information security or network security is ensured through indigenous network security solutions. In general, the National Critical Information Infrastructure Protection Centre National Technical Research Organisation has prescribed guidelines for the protection of national critical information infrastructure to protect critical information infrastructure (CII) from "unauthorized access, modification, use, disclosure, disruption, incapacitation, or destruction".[215] The Computer Information and Security Advisory Group (CISAG), formed in 2001 in the DAE, is in charge of periodic oversight of information systems. It has put in place plans and guidelines to counter cyber-attacks and mitigate any adverse effects. Specific guidelines are under preparation to deal with network-related risks to control and instrumentation systems used in various installations.[216] In addition, regulations require computer-based critical safety systems to have a parallel system. For information security, India has developed

SNAS NAC

- Real-time detection, identification and authentication of end systems in a network
- Automated isolation, threat management and Captive Portal
- Automated detection and isolation of back door entry into network
- Real-time detection of bridging between Intranet and Internet networks

SNAS-NBAD

- Real-time detection and isolation of malicious behavior of end systems related to network traffic, network applications, threat propagation, blended attacks and denial of services attack

ROGUE SYSTEMS DETECTION & ISOLATION USB CONTROL SNAS-SECURITY VISUALIZATION

- Auto topology detection
- Network visualization including end system's security states
- Rogue system visualization
- SNAS-End system application aware firewall
- Dynamic firewalls based on end system's security state
- Role-based Network Access Control & Authentication System

[215] Government of India, National Critical Information Infrastructure Protection Centre, "Guidelines for Protection of National Critical Information Infrastructure," Version 2.0, January 16, 2015. https://nciipc.gov.in/documents/NCIIPC_Guidelines_V2.pdf
[216] Government of India, Ministry of External Affairs, *Nuclear Security in India*, March 2014. https://www.mea.gov.in/in-focus-article.htm?23091/Nuclear+Security+in+India

a secure messaging and voice communication device placed within a mobile device to communicate in a secure manner.

Specifically for nuclear facilities, the Secure Network Access System (SNAS), developed at BARC, is designed with several modules for real-time detection, identification, and authentication of the end-system in a network (SNAS-Network Admission Control).[217] In a presentation on the Indian perspective of cyber security, R.M. Suresh Babu of the DAE explains that the SNAS system is capable of restricting communication with other agencies in the network and force policy compliance, and it can isolate a particular system if found not compliant with the established policies. Its other module can monitor network behavior and detect anomaly and malicious behavior in terms of network traffic (SNAS-Network Behavioral Anomaly Detection).[218] Through a live dashboard, the administrator can have network visualization (SNAS-Security Visualization) to determine if all systems are connected to the network and identify the state of security at any given time. If the systems are found not behaving as expected, it can quickly isolate them. SNAS dynamically changes the rules of the end system application aware firewalls.

The Indian technical and regulatory establishment is undoubtedly striving to ensure that nothing catastrophic happens in case of a cyber-attack, but it is an evolving domain and there is ample scope for India to adopt global best practices. India may seek support from the US Pacific Northwest National Laboratory, which is developing Pack Rat (a physical and cyber risk assessment tool) to integrate physical security and cyber security.

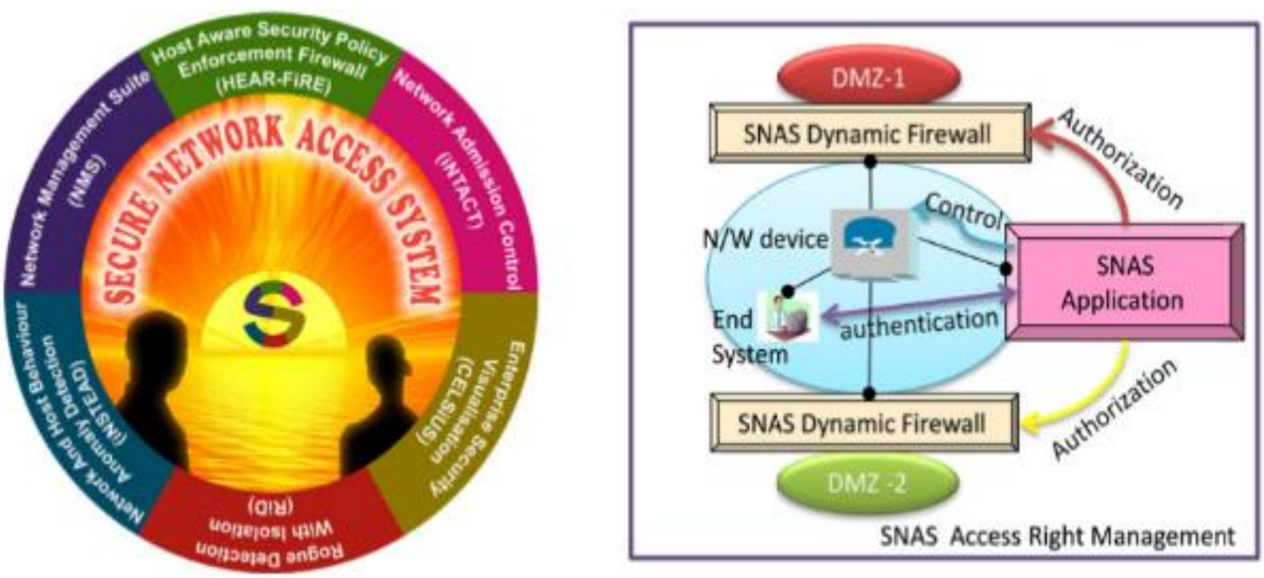

Figure 7. Network Security System

Source: R. M. Suresh Babu, NAS 2013, p. 78.

[217] Gigi Joseph, "Secure Network Access System (SNAS)," BARC Newsletter, Special Issue, October 2014. http://www.barc.gov.in/publications/nl/2014/spl2014/home.html#

[218] R.M. Suresh Babu, "An Indian Perspective on Cybersecurity," in the National Academy of Sciences compiled *India-United States Cooperation on Global Security: Summary of a Workshop on Technical Aspects of Civilian Nuclear Materials Security (2013)*, Washington, D.C.: The National Academies Press, 2013, p. 76. https://www.nap.edu/read/18412/chapter/6#76

4.4.9. Nuclear Forensics

Nuclear forensics techniques are practiced in different contexts in India, including analysis of nuclear fuel samples from reactor cores and radio analytic support for crime investigation and the judicial process. In an answer to a question raised in the Lok Sabha on August 22, 2012, on "whether the Government is equipped with Nuclear Forensics to track the origin in illicit nuclear devices or other radioactive materials which could be used for terrorist purposes," the concerned Minister responded, "The available technical expertise in Nuclear Forensics, employed for Nuclear Material Control and Accounting as well as for detection and characterisation of radioactive materials is also used to identify the material and its origin."[219]

The forensics laboratory in BARC assists police in investigations of crimes. Questions regarding seized items are sent to BARC for identification. In addition, to tackle smuggling and illegal transportation of nuclear materials, the Directorate of Forensic Science Laboratories, Bangalore, has drawn up a comprehensive plan and proposed establishment of a national nuclear forensic science center. According to V. Venugopal, mastering forensic technology for nuclear industry requires a very high level of radioanalytical capability which India lacks currently. Some courses are being conducted but "India is unable to obtain some of the most useful state-of-the-art tools for analysis – secondary ion mass spectrometry (SIMS) a powerful technique that can analyze the isotope composition." [220] Even the thermal ionization mass spectrometry equipment needed for analyzing the minimum sample size is unavailable. Unfortunately, India is not able to procure the latest SIMS technology for fissile material characterization.[221] Therefore, this should be an urgent area for international cooperation and a prime area for collaboration. As one of the objectives of the GCNEP is to enhance nuclear safeguards through various advanced systems (including nuclear forensics), it may coordinate and expedite such international collaborations.

4.4.10. Security of Strategic Assets

Little open-source information is available on the steps India takes to prioritize security of its strategic assets, including nuclear weapons, components, or strategic facilities. It is believed that India's nuclear weapons are in a disassembled and dispersed state. It is important to acknowledge the fact that India adheres to a second-strike nuclear posture that relies on secrecy, and, therefore, has to protect internal safety and security measures from scrutiny, mainly to ensure survivability of its arsenal. The Strategic Forces Command has administrative control of the nuclear forces. The Strategic Armament Safety Authority that functions directly under the Nuclear Command Authority is responsible for all matters relating to the safety and security of India's nuclear and delivery assets at all locations.[222] It is believed that the physical security of warheads and components is provided by a specialized force drawn from the Indian Army.

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[219] Parliament of India, Lok Sabha, "Strengthening of Oversight Process," Unstarred Question No. 1709, Answered on August 22, 2012.

[220] V. Venugopal, "The Emerging Science of Nuclear Forensics," in the National Academy of Sciences compiled report on *India-United States Cooperation on Global Security: Summary of a Workshop on Technical Aspects of Civilian Nuclear Materials Security (2013)*, Washington, D.C.: The National Academies Press, 2013, pp. 110–11. https://www.nap.edu/read/18412/chapter/8#109

[221] ibid

[222] Shyam Saran, "India's Nuclear Weapons Not for National Pride," *The Tribune, Online Edition*, May 9, 2013. http://ris.org.in/images/RIS_images/pdf/tribune-9may%202013.pdf

After the Indo-US civil nuclear deal, India separated its civil nuclear facilities from facilities that are associated with its strategic program. As of September 2018, India has placed 26 nuclear facilities under IAEA safeguards. Although a comprehensive physical security architecture of the civilian facilities is in place (as discussed above), little is known about the physical security arrangement for the strategic nuclear plants. In 2014, the MEA released a document called Nuclear Security in India that states: "Separate institutions and operating procedures exist for nuclear security at India's strategic facilities."[223]

Since 2000, BARC has not been under the regulatory supervision of the AERB. This is a significant move since BARC houses much of India's strategic nuclear program, including the Dhruva reactor. As of now, only the country's civilian nuclear reactors are under the regulatory supervision of the AERB, and the strategic facilities are managed by internal safety committee structures constituted by the facility director.

Undoubtedly, secrecy has been a constant factor ever since India decided to develop operational nuclear forces under the gaze of the nonproliferation regime. The Indian government has revealed only the barest of glimpses of what steps it believes are necessary to ensure deterrence while maximizing safety and security. Except anecdotal reports, there is no official account of India's nuclear weapons inventory and the system used to ensure their safety. Furthermore, India's self-imposed No First Use posture, which is viewed as a stabilizing factor for nuclear South Asia, demands opacity and ambiguity, providing an opportunity for considerable speculation. As India's deterrent [triad] is still in the making, any transparency initiative will have to be limited and certainly on India's terms. If India's status advances from *de facto* to *de jure* nuclear weapon state, which is unlikely, or achieves greater international acceptance owing to its increasing global clout and national confidence, can India afford more nuclear transparency? An inquiry into this question is beyond the scope of this report.

4.5. Lessons Learned

India has not yet suffered a nuclear accident, but industrial incidents of a non-nuclear nature, along with incidents of misconduct inside nuclear facilities, have been reported. As discussed earlier, the only incident involving radiological material took place in 2010 in the Mayapuri scrap market (near Delhi) where an abandoned gamma-irradiator from the University of Delhi was sold to the scrap market without measuring its residual activity. The scrap workers in turn dismantled it, exposing the cobalt-60 pencils, which led to death of one worker and radiation symptoms suffered by two others. According to an article published in the *Journal of Indian Academy of Forensic Medicine*, this incident highlights "the undue negligence on the part of the authorities who had carelessly disposed off the hazardous radioactive materials."[224] The incident was a serious wake-up call for the establishment to monitor and maintain a database of radiation sources utilized in the country.

On the other hand, public opposition to a nuclear project in Kudankulam exposed security concerns related to facility and public safety. Though sporadic, public protests against nuclear projects in India have turned violent in the recent past. During the protest movement around Kudankulam, one or

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[223] Government of India, Ministry of External Affairs, *Nuclear Security in India*, March 2014. https://www.mea.gov.in/in-focus-article.htm?23091/Nuclear+Security+in+India

[224] S.R. Singh, et al., "Fatal Radiation Exposure due to Careless Disposal of Cobalt-60 from a University Lab", *J Indian Acad Forensic Med*, July-September 2013, Vol. 35, No. 3, p. 283.

two thousand protesters surrounded the plant, blocking entry to the facility.[225] On one occasion, approximately 400 fishing boats approached by water, and people attempted to enter the plant's premises.[226] This necessitated deployment of more security forces to ensure safety and security to the nuclear facility. As India has embarked on an ambitious nuclear expansion plan, public opposition might escalate with serious security implications.

4.5.1. Lessons Learned from Mayapuri Incident 2010

The radiation-related death that occurred during the Mayapuri incident of 2010 is unique in India although radiation-related incidents have been reported over the years (see Figure 8). The Mayapuri incident highlighted the dangers of unaccounted radioactive sources used in various sectors. Though the Mayapuri incident is purely a nuclear-safety related issue, such situations can be manipulated or misused by anti-social elements having nefarious designs.

Year	Reported location	Type of event /exposure	Source	Death	Injury
1967[(21)]	New Delhi	Teletherapy unit, local	^{60}Co	0	1
1972[(22)]	Mumbai	X-ray equipment/local	—	0	1
1974[(22)]	Mumbai	X-ray equipment, local	—	0	1
1982[(19)]	Vikhroli, Mumbai	Lost source during transport, TBI	^{192}Ir	0	1
1982[(20)]	Mulund	Radiography, TBI	^{192}Ir	0	1
1985[(20)]	Vishakhapatnam	Radiography, local	^{60}Co	0	2
1985[(20)]	Yamunanager	Radiography, local	^{192}Ir	0	2
1989[(20)]	Hazira	Radiography, TBI	^{192}Ir	0	1
2010	Mayapuri	Improper disposal, TBI	^{60}Co	1	7

Source of information: database of radiological incidents and related events[(1)].
Co, cobalt; Ir, iridium; TBI, total body irradiation.

Source: A. B. Dey, et al., "Notice of Retraction of Radiation Accident at Mayapuri Scrap Market, Delhi, 2010," Radiation Protection Dosimetry (2012), Vol. 151, No. 4, p. 646.

Figure 8. Reported Radiation Related Incidents in India and Their Outcome

The Mayapuri incident brought to the fore the violation of protocols by an educational institution and significant deficiencies in legislation, surveillance and regulations for radiation protection in India. However, important lessons have been learned and actions have been initiated to address the deficiencies. Following are some of actions taken following the incident:

1. The AERB has developed a comprehensive database of radiation sources utilized in the country and instituted a very successful e-LORA (e-licensing of Radiation Application) platform for complete automation and to facilitate end-to-end licensing of facilities using radiation sources.
2. The AERB has banned the use of the radioactive isotope cobalt for research in the universities.
3. The University Grant Commission has issued comprehensive guidelines on the usage of radioactive material by universities and colleges across the country.

[225] M.R. Srinivasan, "Public Concerns about Nuclear Energy and Development Efforts," in the National Academy of Sciences compiled report on *India-United States Cooperation on Global Security: Summary of a Workshop on Technical Aspects of Civilian Nuclear Materials Security (2013)*, Washington, D.C.: The National Academies Press, 2013, p. 12.

[226] "Fishermen Lay Siege to Kudankulam Nuclear Plant," Rediff News, Rediff.com, October 8, 2012.

4. A task force for radiation accidents was constituted by the Ministry of Health and Family Welfare for framing protocol for the medical fraternity to respond to radiation-related emergencies.

4.5.2. Public Acceptance of Nuclear Projects

According to information presented in a 2010 Nuclear Security Summit, public acceptance of the use of nuclear materials for nuclear power and consequent support for nuclear energy projects is largely based on the assurance by concerned authorities that "nuclear materials will remain under control and appropriate use, and that the public will not be harmed either by a safety incident or a security incident."[227] Imposition of unilateral decisions for nuclear projects have definite safety-security implications. Greater public acceptance and support will help ensure greater safety-security of nuclear installations. The protest against the Kudankulam project and consequent delay was, according to a major Indian newspaper, "a public relations disaster".[228] Lately, the government of India and other nuclear agencies have embarked on a mission to calm public fears. The DAE, the AERB, and the NPCIL have all addressed safety and security issues through various public outreach programs and their corporate social responsibility activities.

[227] "Introduction and Overview of Civilian Nuclear Materials," in the National Academy of Sciences compiled *India-United States Cooperation on Global Security: Summary of a Workshop on Technical Aspects of Civilian Nuclear Materials Security (2013)*, Washington, D.C.: The National Academies Press, 2013, p. 7.
[228] "Public Acceptance Paramount While Setting up Nuclear Plants," *The Hindu*, September 26, 2011.

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5. NUCLEAR SECURITY CULTURE IN INDIA: AN EVALUATION

In India, nuclear security has traditionally been subsumed within the broader nuclear safety framework given that the AERB is tasked with the oversight of both safety and security. The various legal and institutional frameworks in the country were instituted with safety considerations in mind. Given the intertwined nature of safety and security, one would have expected more transparency within the country's nuclear security infrastructure since a healthy safety culture, by definition, demands a certain amount of transparency. However, transparency regarding nuclear security, or even safety for that matter, in the country's nuclear establishment is hardly visible, even as India's willingness to be transparent has seemingly increased over the years. There are a number of reasons for the lack of transparency in India's nuclear establishment. The country's distinctive nuclear past, including many years of isolation, and a mix of civilian and strategic nuclear programs, have given rise to heightened levels of caution within the country's nuclear establishment. Additionally, given that India's nuclear program was under sanctions and isolated by the international community after the 1974 nuclear explosion, a culture of extreme secrecy within the establishment ensued, ensuring that the nature of the country's nuclear program was not disclosed to outsiders.

Secrecy is not always a bad thing. It can be both positive and negative as far as nuclear security is concerned. While a certain amount of secrecy and sense of threat will contribute to enhancing security measures in nuclear installations, it is also possible that extreme secrecy will reduce accountability and internal checks and balances. However, there is a new-found belief in India that it is no longer an isolated state in the global nuclear order and that it is, therefore, important to participate in global norms and rules. For instance, the IAEA was invited by India to conduct a peer review of the Indian nuclear safety regulatory system in 2015.[229] There is also a great sense of urgency among the Indian political leadership on nuclear security matters. This is evident from the participation of the Prime Minister and the External Affairs Minister in the Nuclear Security Summits and their statements indicating the seriousness with which India approaches nuclear security matters. Former Prime Minister Dr. Manmohan Singh stated at the 2010 NSS that "Nuclear security is one of the foremost challenges we face today." Likewise, the then External Affairs Minister declared in the Hague Summit that "India fully shares the continuing global concern on possible

INSTITUTIONAL / LEGAL / OPERATIONAL CHANGES

- Nuclear Control and Planning Wing (2013)
- Crisis Management Group
- Inter-ministerial Counter Nuclear Smuggling Team
- Global Centre for Nuclear Energy Partnership (GCNEP)
- AERB Revised guide for Safe Transport of Radioactive Material – AERB/NRF-TS/SC-1 (Rev.1) 2016
- AERB Committee for Revising Security Aspects (CRSA) and Working Group
- Directorate of Regulatory Inspection (AERB)
- Media Briefings on India's Position on Nuclear Security by MEA
- National Progress Report to NSS

[229] "IAEA Mission Concludes Peer Review of India's Nuclear Regulatory Framework," March 27, 2015. https://www.iaea.org/newscenter/pressreleases/iaea-mission-concludes-peer-review-indias-nuclear-regulatory-framework

breaches of nuclear security."[230] At the most recent summit, Prime Minister Narendra Modi committed to concrete steps that will improve India's nuclear security agenda. Ever since, India has been actively implementing various undertakings it had pledged at the NSS meetings. Broadly, one can observe a subtle attitudinal change taking root in India with its willingness to showcase security arrangements through various public statements, press notes, annual reports, and national progress reports. Meanwhile, many institutional, legal, and operational reforms have been undertaken to maintain international regime compliance.

In short, it would be appropriate to argue that India's nuclear security approach is based on the foundation and belief that "credible threat exists, and that nuclear security is important." In our considered opinion, we believe India needs to further strengthen its institutional, legal, and physical infrastructure relating to nuclear security in order to ensure the security of its nuclear establishment. We also believe that the country does have a strong institutional and physical foundation that can be further enhanced and strengthened. It is encouraging to see that since this paper was first written in 2015, India has come a long way in doing precisely that.

5.1. Absence of an Overarching Security Apparatus

One issue that should be taken seriously by the government of India regarding nuclear security is the absence of an overarching security apparatus to safeguard the country's nuclear security installations. As mentioned earlier, the physical security of nuclear installations is provided by a mix of multiple organizations such as the CISF, the local police, and sometimes even private security organizations. On the other hand, material accounting is handled by the DAE, and the review of security practices is the responsibility of the AERB. Note that this is the situation on the civilian side alone. Thus, there are multiple organizations in charge of the various aspects of nuclear security in the country, resulting in non-uniform nuclear security culture, norms, and standard operating procedures. While it is not impossible to deal with multiple organizations and agencies, it takes far more effort and the possibility of mistakes and sabotage is significantly higher.

5.2. Regulatory Autonomy

It may be noted that there was no single regulatory mechanism prior to 1983 when the AERB was established through a gazette notification by the government of India. Prior to 1983, security and safety regulation was carried out by an internally constituted committee in each facility.

The AERB's regulatory powers are argued to be limited as it is de facto autonomous. The Public Accounts Committee of the Parliament of India in its 90th report pointed out that "the legal status of the AERB continues to be that of an authority subordinate to the Central Government, with powers delegated to it by the latter."[231] It is the government of India that appoints the head of the regulatory body and provides the necessary funding. Moreover, the head of the AERB reports to the Chairperson of the Atomic Energy Commission, who is also the Secretary in the DAE, which creates the situation of the regulator reporting to the promoter of nuclear projects. This is a potential conflict-of-interest and has implications for the extent and quality of oversight by the regulatory authority. In its current form, the proposed NSRA also does not provide for a truly autonomous regulator.

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[230] "Khurshid: Nuclear Terrorism Serious Threat to Global Peace," *The Indian Express*, March 26, 2014. http://indianexpress.com/article/india/india-others/khurshid-nuclear-terrorism-serious-threat-to-global-peace/

[231] Government of India, Public Accounts Committee 2013-2014, "Activities of Atomic Energy Regulatory Board," Report No. 90, p. 4, https://eparlib.nic.in/bitstream/123456789/64647/1/15_Public_Accounts_90.pdf

5.3. Program Confusions

Some Indian reactors that are connected to the grid and producing electricity are marked "strategic." The difference between these reactors and those that are "civilian" is the length of irradiation, but confusion remains regarding the status of the spent fuel generated out of these reactors. Yet, it is conceivable that there could be two sets of standards and different organizations involved in managing safety and security of each, simply because of this semantic (or perhaps operational) difference. This could be seen as problematic in the public eye from a consistency and regulatory point of view.[232]

5.4. Conceptual Tensions

There are conceptual tensions at every level of nuclear security: between safety and security; between physical protection and material protection and accounting; between the use of technology and manpower; and between counter-intelligence and "need to know" system.[233] Such tensions need to be addressed to achieve a certain level of balance that would be acceptable for India. The accountability system in the country needs to be based on how these tensions are resolved. We have seen in failures in the US where internal accountability was lacking.[234]

5.5. An Introspection

No amount of security can be security enough; as threats evolve every endeavor to ensure security should be dynamic. Therefore, there is always scope for improvement. There is no question that India wants to strengthen its nuclear security architecture. The question is how dynamic and efficient the system should be given the magnitude of threats the world faces today. Undoubtedly India has evolved and nurtured a coherent nuclear security culture, but complacency should not prevail. It is worth recalling the words of Kiyoshi Kurokawa, the Chairman of the Fukushima Nuclear Accident Independent Investigation Commission, on the Fukushima nuclear accident:

> "What must be admitted — very painfully — is that this was a disaster 'Made in Japan.' Its fundamental causes are to be found in the ingrained conventions of Japanese culture: our reflexive obedience; our reluctance to question authority; our devotion to 'sticking with the program'; our groupism; and our insularity . . . nuclear power became an unstoppable force, immune to scrutiny by civil society. Its regulation was entrusted to the same government bureaucracy responsible for its promotion."[235]

Anyone familiar with the Indian nuclear establishment should see that much of what Kurokawa says about the Japanese nuclear safety-security culture is applicable to India (and any other country for that matter) and seek ways for them to be addressed.

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232 Inputs via email from Toby Dalton, Deputy Director, Nuclear Policy Program, Carnegie Endowment for International Peace, Washington D.C. July 2014.

233 Ibid.

234 Ibid.

235 Kiyoshi Kurokawa, *The National Diet of Japan: The Official Report of the Fukushima Nuclear Accident Independent Investigation Commission*, 2012. http://ieer.org/wp/wp-content/uploads/2012/07/Fukushima_NAIIC_report_lo_res3.pdf

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6. RECOMMENDATIONS FOR ENHANCING NUCLEAR SECURITY GOVERNANCE, INSTITUTIONS, INSTRUMENTS, AND CULTURE

This study has identified a number of areas where we believe more needs to be done to improve the nuclear security architecture and culture in India. Based on our findings, we put forward the following suggestions for debate and consideration by the government of India and the international community.

6.1. Recommendations for India

1. Increase Transparency
   - Demonstrate more confidence and clarity in the essential elements of the country's nuclear security practices. While there has been far more demonstration of confidence and clarity over the years, more public outreach with regard to nuclear matters would be helpful.
   - Make transparency a key feature of the country's nuclear security culture.
   - Develop a comprehensive white paper on security and safety measures aimed at the domestic and international audience and stakeholders.
2. Enhance the Autonomy of the Regulatory Body
   - Ensure complete autonomy (de jure) of the regulatory body from the promoting agency through appropriate legislation.
   - Include scientists, civilian auditors, environmentalists, etc. into the regulatory oversight body.
   - Constitute a bipartisan body to select the members of the regulatory body.
   - Reintroduce the lapsed NSRA bill with necessary amendments to create a more efficient and accountable nuclear regulatory body.
3. Strengthen National Nuclear Safety-Security Culture
   - Reexamine organizational issues identified in the Fukushima accident investigation, including "reflexive obedience, reluctance to question authority, devotion to 'sticking with the program', and vested interest, groupism, and insularity."[236]
   - Set up a high-level committee to explore how prevailing trends in India's nuclear security system can be addressed.
   - Prepare and publish reports about nuclear/radiological related incidents and share measures taken and lessons learned
   - Create a specialized body to manage public acceptance issues involving nuclear energy projects and nuclear knowledge management
4. New Areas to Consider
   - Create unified security command/structure/requirements for the civilian nuclear installations.
   - Create a special division within the CISF, or even a new specialized nuclear security force, to address nuclear security.
   - Create an agency to oversee and regulate strategic nuclear facilities.
     - Consider the strategic importance of declaring thorium-bearing areas and monazite sands as exclusive zones and providing them oversight and adequate security.

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[236] Ibid.

- Enhance the security of radiological materials, devices, and facilities considering their increased application.
- Equip major Indian seaports with technology aligned with the Container Security Initiative.
- Conduct periodic reviews of standard operating procedures in place for guarding against insider threats.

6.2. Recommendations for the International Community

- Help mainstream India in the global nuclear order. Pursue India's entry into the export control organizations, especially the NSG.
- Invite India to observe nuclear security training, practices, simulation exercises, etc. in other nuclear states and vice versa. The AERB-USNRC bilateral meetings to and the Indo-US Technical Exchange Programme on Security by Design are steps in the right direction.[237]
- India and USA may consider conducting Radiological Search Joint Exercises, and collaborate in nuclear accident training exercise (NUWAIX)
- India and the NSS process should consider convening regional Nuclear Security Summits.

[237] Government of India, Atomic Energy Regulatory Board, "Strengthening Nuclear Safety and Security," *Annual Report 2017*, p. 105.

7. NEXT STEPS

Ever since the NSS process, India has promptly joined the global efforts and complied to the global standing on nuclear safety-security; however, no out-of-the-box initiatives have been undertaken by it yet to demonstrate that New Delhi is capable and willing to spearhead in this domain. This section identifies some of the short-term, intermediate-term, and long-term steps we think could be taken by the Indian government to strengthen the safety and security of India's civilian nuclear facilities and material while setting trend for others to follow.

1. Short Term (1–2 years)
   - Introduce theoretical and practical aspects of nuclear security in university courses on arms control/disarmament, nuclear strategy, nuclear energy, etc.
   - Conduct a comparative study on the nuclear security structures of various countries and determine what aspects are applicable in Indian conditions.
   - Re-initiate debates in the country on the NSRA legislation through mass media.
2. Intermediate Term (2–5 years)
   - Hold a regional preparatory workshop (formal or informal) in South Asia to explore the possibility of holding a regional Nuclear Security Summit.
   - Prepare a draft action plan, based on the practices and experiences of other countries, for securing radiological facilities in India. Necessary training may be given to the personnel in key radiological facilities in the country on nuclear security.
   - Create a pool of concerned citizens both from technical and social science background to create a group of 'nuclear cheerleaders' to attend dedicatedly public concerns and knowledge/information relating to nuclear energy projects.
3. Long Term (ongoing)
   - Promote interface and collaboration among universities, think tanks, and nuclear establishment in India to discuss and deliberate on nuclear security matters.
   - Promote collaborative research on nuclear security between Indian and international think tanks and universities.

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