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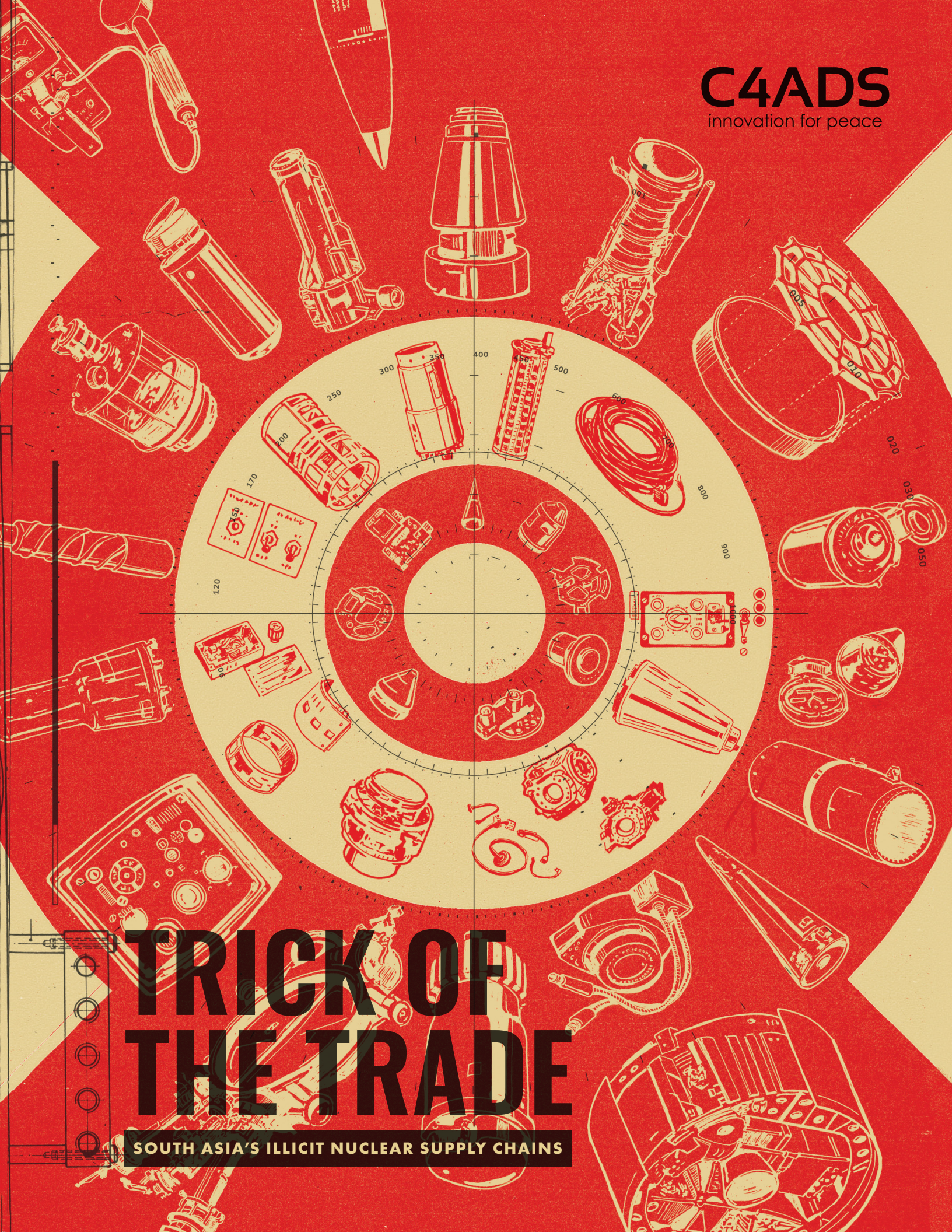
innovation for peace



TRICK OF THE TRADE

SOUTH ASIA'S ILLICIT NUCLEAR SUPPLY CHAINS

ABOUT C4ADS

C4ADS (www.c4ads.org) is a 501(c)(3) nonprofit organization dedicated to data-driven analysis and evidence-based reporting of conflict and security issues worldwide. We seek to alleviate the analytical burden carried by public sector institutions by applying manpower, depth, and rigor to questions of conflict and security. Our approach leverages nontraditional investigative techniques and emerging analytical technologies. We recognize the value of working on the ground in the field, capturing local knowledge, and collecting original data to inform our analysis. At the same time, we employ cutting edge technology to manage and analyze that data. The result is an innovative analytical approach to conflict prevention and mitigation.

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COVER IMAGE

Front cover art by Brian G. Payne

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OUR TECH PARTNERS

C4ADS would also like to thank its technology partners, whose software and systems were integral to the project's success.

ANALYSIS POWERED BY Palantir aws WINDWARD

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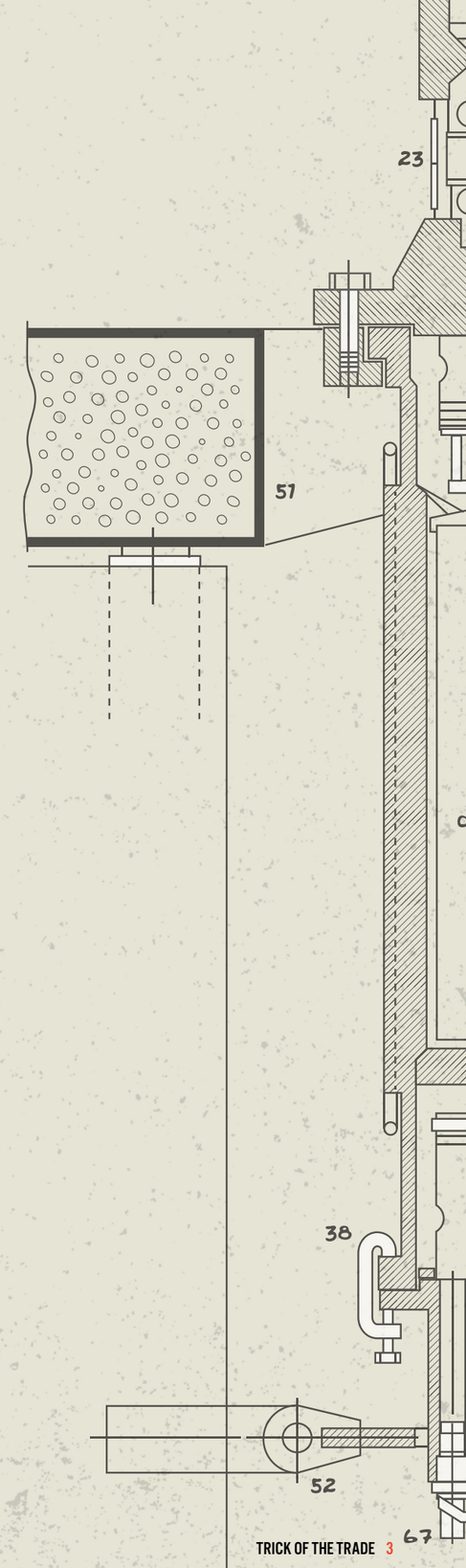
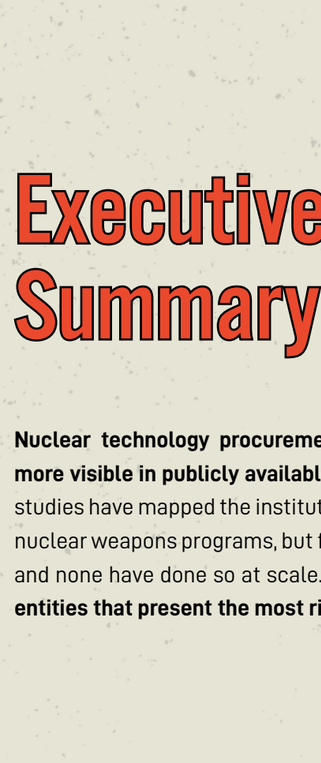
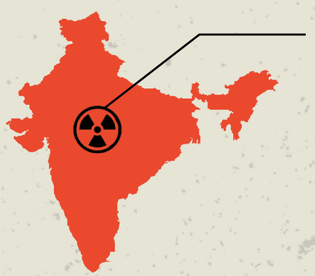


Executive Summary

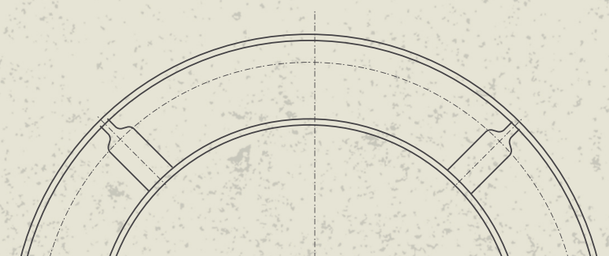
Nuclear technology procurement networks in both Pakistan and India are larger and more visible in publicly available information (PAI) than previously documented. Previous studies have mapped the institutions and infrastructure underlying the Indian and Pakistani nuclear weapons programs, but few have mapped international procurement supply chains, and none have done so at scale.[1, 2, 3, 4, 5, 6] **Using millions of trade records, we isolated those entities that present the most risk for illicit dual-use trade.**



In the case of Pakistan, C4ADS found that in addition to the more than 100 entities listed by national export control authorities, 46 entities demonstrate high risk of illicitly procuring for Pakistan's nuclear program based on their trade activity and network structures.[7, 8, 9]



In the case of India, C4ADS used public tender data to identify 222 companies that contracted with nuclear facilities outside of the oversight of International Atomic Energy Agency (IAEA) safeguards. Of these 222 companies, 86 had contracted with more than one unsafeguarded facility.



INDIAN AND PAKISTANI NUCLEAR PROCUREMENT NETWORKS BEHAVE DIFFERENTLY – BUT BOTH ARE VISIBLE THROUGH THE STUDY OF TRADE DATA.

- Pakistani nuclear procurement companies, who face strict international export control regulations and Nuclear Suppliers Group (NSG) trade restrictions, are more likely to procure through the use of transshipment hubs.[10] Customs and trade data demonstrate that the top 33 suppliers of Pakistan's known procurement companies are located in mainland China (34%), Hong Kong (18%), the United Arab Emirates (UAE) (9%), the United States (9%), Germany (6%), Italy (6%) and Singapore (6%). Hong Kong, the UAE, and Singapore are common transshipment hubs also associated with North Korean and Iranian proliferation.[11] China, the United States, Germany, and Italy are NSG members, obligated to avoid supplying unsafeguarded or military facilities in India and Pakistan.[12, 13, 14]
- Indian companies tend to purchase more directly from NSG countries. Of the 124,089 imports from 64 countries between January 2017 and July 2019 associated with the 87 Indian companies known to have procured for more than one unsafeguarded facility, 92% were from companies in NSG member states including Germany, China, United States, South Korea, and the UK. India does hold a waiver from the NSG exempting the country from certain nuclear trade restrictions. However, this exemption does not apply to facilities outside of IAEA safeguards.[15]

FROM OUR BROADER ECOSYSTEM MAPPING, WE CAN IDENTIFY SPECIFIC ENTITIES THAT MAY REPRESENT ELEVATED RISK.

- For Pakistan, we identify a Hong Kong-based supplier, Sunton Tech (HK) Ltd, which supplies companies in Pakistan that are listed by national export control authorities, companies that pose elevated risk of illicitly procuring for Pakistan's nuclear program, and companies associated with the Pakistani military. This provider has also sought to acquire goods from a U.S.-based vendor of technology with missile applications.
- For India, in the case of the Rare Materials Plant, an unsafeguarded Indian centrifuge enrichment facility which produces highly enriched uranium that could be used as naval fuel or in nuclear weapons, we identified seven Indian companies that have been contracted to procure products for use in the facility. These contracting companies have purchased primarily from vendors in Japan, China, Germany, South Korea, and the United States between January 2017 and July 2019.

The findings from this report are relevant for private sector companies, national export control authorities, and multinational organizations, who are at the frontlines of nonproliferation compliance. On 21 April 2020, the US Nuclear Regulatory Commission (NRC) ordered the suspension of the general license authority under NRC regulations for the exports of nuclear byproduct material to Pakistan, which reflects the continued significance of South Asia in global nuclear security, and its salience for US national security.* We assess that the supply chains of nuclear technology procurement networks in Pakistan and India are visible in PAI, and thereby vulnerable to enhanced risk screening and enforcement action. The methodologies we describe in this report can help to identify the companies engaged in both licit and illicit nuclear procurement in India and Pakistan, their foreign suppliers, and the items they procure. We hope these methodologies can equip key stakeholders to better identify and understand not just national, but also entity-level, exposure to procurement activities and take steps to disrupt and dismantle illicit supply chains that sustain the stockpiling of nuclear weapons.

* U.S. Nuclear Regulatory Commission. (2020, April 21). Order Suspending General License Authority To Export Byproduct Material to Pakistan. Federal Register. Retrieved from: https://www.federalregister.gov/documents/2020/04/21/2020-08412/order-suspending-general-license-authority-to-export-byproduct-material-to-pakistan. Archived at: https://web.archive.org/save/https://www.federalregister.gov/documents/2020/04/21/2020-08412/order-suspending-general-license-authority-to-export-byproduct-material-to-pakistan

Glossary

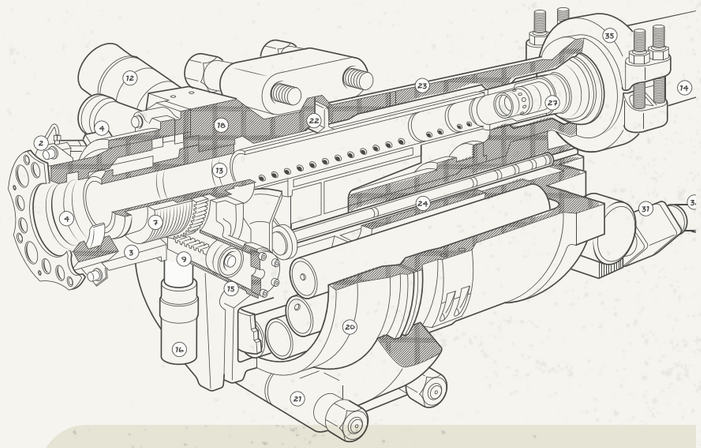
ACTIVITY-BASED ANALYSIS	Activity-based analysis is "focused on the activity and transactions associated with an entity, population or area of interest," and analyzes interactions over time.16 Activity-based analysis differs from other modes of analysis in that it defines its targets through observation, as opposed to observing a specific, pre-selected target.[17]
BILL OF LADING-LEVEL TRADE DATA	Bill of lading-level trade data is customs-derived data on a country's trade that includes information on all shipments to a given country in a given period, and that features details on consignor (shipper) and/or consignee (receiver), commodity, and/or commodity code. Bill of lading-level trade data can include maritime shipments, air cargo, and overland cargo. In certain rare cases, customs data may be vulnerable to interference by corrupt or politically-motivated state actors who may misrepresent or fail to record shipments.
END USER	The ultimate recipient and user of an exported product.[18] End users are distinct from other parties that might receive an export, such as a forwarding agent.[19] End users can be people, companies, or government institutions.
ENTITY	Any business, organization, or individual.
EXPORT-CONTROLLED DUAL-USE GOODS	This report defines export-controlled dual-use goods as those specifically listed as export-controlled nuclear and nuclear dual-use items in product lists contained in the NSG Part Two guidelines.[20] Potential dual-use goods are defined as any product with potential nuclear dual-use application, and encompass categories such as HS codes that apply to export-controlled dual-use goods, or goods that, depending on their qualities, may be export-controlled. This report focuses on nuclear dual-use goods rather than direct-use goods, "trigger list" items, or radiological materials.
LISTED ENTITY	In the context of this report, a listed entity is an entity that appears on the US Department of Commerce Bureau of Industry and Security (BIS) "Entity List" or the Japan Ministry of Economy, Trade and Industry (METI) "End User List."[21, 22] The BIS Entity List subjects foreign persons to license requirements for the export of specified items based on "activities contrary to U.S. national security or foreign policy interests."[23] Notes accompanying the listing of entities can indicate if the entities pose a proliferation concern. The METI End User List applies similar restrictions to foreign entities involved in "activities such as the development of weapons of mass destruction and other items."[24]
NUCLEAR SUPPLIERS GROUP (NSG)	The Nuclear Suppliers Group (NSG) is "a group of nuclear supplier countries that seeks to contribute to the non-proliferation of nuclear weapons through the implementation of two sets of Guidelines for nuclear exports and nuclear-related exports."[25] The NSG publishes guidelines for nuclear and dual-use transfers which include annexes detailing nuclear direct-use and nuclear dual-use goods.[26]
PROLIFERATION ACTIVITY	Actions taken by entities to develop or improve nuclear weapons capabilities or assist others in developing or improving such capabilities. This can include "horizontal proliferation," the spread of nuclear weapons across non-nuclear weapons states, and "vertical proliferation," the growth and development of more advanced or effective nuclear weapons by states already possessing such weapons.[27]
PROLIFERATION RISK	Classification of entities and activities based on heuristics derived from known proliferators and other illicit actors.
PUBLICLY AVAILABLE INFORMATION (PAI)	Any general media, social media, public record, commercial database, gray literature, audio, imagery, or expert interview that can be legally purchased, obtained, or created by the public.[28]
SOCIETAL VERIFICATION	The concept of incorporating nontraditional stakeholders into verification and transparency regimes to increase the likelihood that violations of international commitments are detected.[29]
TREATY ON THE NON-PROLIFERATION OF NUCLEAR WEAPONS (NPT)	A multilateral treaty aimed at limiting the spread of nuclear weapons including three elements: (1) non-proliferation, (2) disarmament, and (3) peaceful use of nuclear energy.[30] These elements constitute a "grand bargain" between the five nuclear weapon states and the non-nuclear weapon states (NNWS).[31] The NPT has the widest adherence of any arms control agreement, with only South Sudan, India, Israel, and Pakistan remaining outside the treaty, and North Korea having announced its withdrawal in 2003.[32] The IAEA verifies NNWS compliance with commitments under the NPT to not acquire nuclear weapons.[33] Article III of the NPT requires NNWS to conclude agreements with the IAEA to safeguard all nuclear materials in all peaceful nuclear activities.[34]
UNSAFEGUARDED FACILITY	A location where the IAEA has not applied measures to ensure that specified nuclear material, non-nuclear material, services, equipment, facilities, and information are not used for the manufacture of nuclear weapons or any other nuclear explosive devices or to further any military purpose. This includes facilities not subject to an IAEA Safeguards agreement and facilities that are undeclared or clandestine. Facilities outside of safeguards are a proliferation concern.[35, 36]

Introduction:

Commercial Procurement in the Pakistani and Indian Nuclear Programs

The Indian and Pakistani nuclear weapons programs represent a grave international security risk. Both countries continue to actively grow their nuclear stockpiles and remain locked in a decades-long security competition that has resulted in three wars and numerous militarized crises since 1947.[37] Both countries are declared nuclear weapons states,[38, 39] and in 1999 became the first two countries in history to wage a large-scale but low-intensity conflict under the nuclear umbrella.[40] There are, however, clear differences in the two programs.

Pakistan has an expanding nuclear arsenal, which could grow to a stockpile of 220 to 225 warheads by 2025, despite international restrictions on its nuclear procurement.[41] Pakistan is not a signatory of the Nonproliferation Treaty (NPT), the Comprehensive Test Ban Treaty (CTBT), or a member of the Nuclear Suppliers Group (NSG), yet it maintains an active nuclear weapons program.[42] Estimates of Pakistan's stores of weapons-grade fissile material and warheads vary across sources, but the International Panel for Fissile Material (IPFM) concluded in 2015 that Pakistan possesses enough fissile material to manufacture more than 200 weapons.[43] The Federation of American Scientists (FAS) estimated in 2018 that Pakistan had between 140 to 150 warheads.[44] Moreover, the IPFM estimates that between 2010 and 2014, Pakistan added 500kg of highly enriched uranium (HEU) and 90kg of weapons grade plutonium (WgPu), an increase of 19% and 90% to its HEU and WgPu stocks respectively.[45] FAS anticipates that Pakistan could grow its stockpile to between 220 and 250 warheads by 2025.[46] This ongoing trend has led observers to characterize Pakistan as having "the world's fastest-growing nuclear stockpile."[47]



IAEA SAFEGUARDS ↓

The International Atomic Energy Agency's Safeguards are technical measures meant to ensure that specified nuclear material, non-nuclear material, services, equipment, facilities, and information are not used for the manufacture of nuclear weapons or any other nuclear explosive devices or to further any military purpose.[48] Safeguards are used to verify that nuclear facilities are not misused and nuclear materials are not diverted from peaceful uses.[49] Facilities outside of IAEA Safeguards, or "unsafeguarded facilities," have no such assurances.[50] Without IAEA verification of the activities and materials in a facility, it is possible that a nuclear facility may be used for the benefit of a weapons program, or that materials in those facilities may be illicitly transferred, or "diverted," to a military nuclear facility.[51, 52]

Under Article 3 of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), each Non-Nuclear Weapons State — like India and Pakistan — is required to conclude a safeguards agreement with the IAEA.[53] India and Pakistan are not parties to the NPT, but have item-specific Safeguards Agreements, meaning that the IAEA can apply Safeguards only to specified nuclear facilities.[54] Both India and Pakistan operate military nuclear facilities and nuclear facilities outside of IAEA Safeguards.[55]

India also continues to develop its nuclear arsenal, though with fewer international constraints on its procurement than Pakistan.[56, 57] The International Panel on Fissile Materials estimates that India has produced 600 kilograms of weapons grade plutonium, sufficient to produce 150-200 warheads.[58] Based on research by the Federation of American Scientists (FAS), India is believed to have produced 130 to 140 warheads.[59] FAS also finds that India's ongoing missile development requires the production of more warheads, and anticipates that its arsenal could expand to 200 weapons by 2025.[60, 61] India is the only non-NPT country that is able to "buy [nuclear] reactors, fuel and technology from international markets" due to a waiver from the Nuclear Suppliers Group (NSG).[62, 63] A number of India's civilian nuclear facilities have been placed under IAEA safeguards, but other ostensibly civilian facilities remain outside of safeguards.[64] India's unsafeguarded civilian nuclear facilities could produce nuclear materials for use in its weapons program.[65, 66] According to NSG guidelines, NSG members have a responsibility to ensure that nuclear dual-use transfers are not made to facilities conducting "explosives activities," "unsafeguarded fuel cycle activity," or when there is "unacceptable risk of diversion" to such activity.[67] Additionally, the United States exercises far fewer entity-specific restrictions in regards to India as compared to Pakistan, though some Indian entities are included on the US BIS Entity List, such as the Bhabha Atomic Research Center (BARC) and all nuclear reactors, reprocessing and enrichment facilities that are not under IAEA safeguards (excepting Kundankulam 1 and 2).[68]

Illicit procurement of sensitive technology has been significant for both the Indian and Pakistani nuclear weapons programs.[69, 70, 71, 72] Nascent nuclear weapons programs have historically lacked indigenous capabilities for manufacturing the precision components necessary to produce fissile material for weaponization.[73, 74] Even where programs have developed self-sufficiency in one aspect of production, it is often necessary, or simply more cost-effective, to source other components from abroad.[75] Pakistan continues to actively procure foreign-produced nuclear dual-use technology for its nuclear weapons program.[76] Although India's improved indigenous production capability may have reduced its need for illicit procurement, the demands of India's nuclear program likely necessitate continued procurement of technology from abroad.[77, 78] This report finds that companies that have received procurement contracts for India's unsafeguarded and military nuclear facilities have purchased products from abroad.

In most cases, the procurement of nuclear technology involves the purchase or shipment of goods.[79] **This commercial activity leaves a trail of publicly available information (PAI) through trade, corporate, flight, vessel, and other data.** Each of these data points provides an indicator that can be used to identify proliferation risk. The challenge, then, is to identify, aggregate, and synthesize these risk indicators within vast amounts of disparate data. In doing so, our report demonstrates that effectively leveraged PAI and activity-based analysis can allow the private sector, government, and international organizations to better detect and mitigate the nuclear threat in South Asia by monitoring, and, where necessary, disrupting supply chains that support nuclear weapons programs.

Methodology

DATA ENGINEERING

We began by producing a list of all entities in Pakistan known to have illicitly procured for nuclear facilities (the Pakistani "Known Entities"), using current and historical lists published by the US Department of Commerce Bureau of Industry and Security (BIS) and the Japanese Ministry of Economy Trade and Industry (METI).[80, 81] Analysts screened trade data for companies that appeared on these lists, using fuzzy searches to account for inconsistencies in company names across trade records.[82]

C4ADS produced lists of entities known to have procured for India's unsafeguarded nuclear facilities (the Indian "Known Entities") by using publicly available tenders. C4ADS standardized and fused tender data from multiple distinct sources to produce a dataset of more than 40,000 nuclear-relevant tenders.[83] Analysts structured these datasets using PySpark in Palantir Foundry and standardized the names of companies and facilities. This allowed analysts to isolate tenders for procurement for unsafeguarded facilities which had previously been identified by Harvard's Belfer Center and Kings College London's Project Alpha.[84, 85, 86]

C4ADS derived trade data from our overall trade data holdings, which include more than 750 million rows of trade data, covering trade to and from 255 different jurisdictions. In the case of Pakistan, C4ADS identified **more than 4 million trade records** covering four years of bill of lading-level trade data. In the case of India, analysts used **more than 122 million trade records** covering three years of bill of lading-level trade data. Analysts structured these datasets using PySpark in Palantir Foundry, a data integration and analysis platform. This included standardizing, fusing, cleaning, and formatting schema for 95 constituent raw trade data files for India and 46 constituent raw trade data files for Pakistan. For all addresses in trade data involving Pakistan, analysts derived coordinates using Google's geocoding API. This allowed for investigations into co-located companies and areas of concentrated high-risk activity.

ACTIVITY-BASED ANALYSIS

Activity-based analysis studies interactions of entities over time.[87] At C4ADS, analysts use this mode of analysis to map ecosystems to derive trends and typologies that elevate the higher-risk entities. These entities can then be vetted through targeted investigation by a human analyst. By applying activity-based analysis to trade data and other forms of PAI in Pakistan and India, we were able to identify previously unknown entities that have likely engaged in the procurement of nuclear technology for unsafeguarded nuclear facilities in each country. This approach has utility across a range of applications, from private sector compliance to societal verification.[88]

The execution of this methodology differed for India and Pakistan, as data access and international regulatory conditions are different for each country. The specifics of the India and Pakistan contexts are addressed in their respective sections in this paper.

LIMITATIONS

As with any analysis of publicly available information, this methodology has to contend with incomplete data and uncertainty. These challenges appear as a result of data availability, incomplete knowledge, and deliberate efforts by illicit networks to obfuscate their activities. Although activity-based analysis studies interactions over time to assist analysts in filtering data for high-risk entities, inaccurate assumptions and incomplete data can result in false positives or the possibility of missing relevant entities entirely. The intervention of analysts later in the process reduces the chances that false positives will be escalated in the final analysis, but it does not account for false negatives that occurred earlier in the analytical process.

These methodologies are not suited to capturing the smuggling of items across borders, thereby evading customs and other record-keeping systems entirely.[89] Additionally, the cases addressed in this report concern previously unidentified actors within known programs, rather than unknown clandestine programs, which are likely much more difficult to detect.

C4ADS uses official corporate records and trade data wherever available to attempt to verify corporate holdings and commercial relationships. However, this information represents a snapshot of corporate and trade activity at a given time: records may not be updated regularly, may not be consistent or wholly accurate, and may not have the same standards of reporting across jurisdictions, among other limitations. In addition, public records do not reveal all details of operations of a company or relationships between entities. Therefore, C4ADS limits its analytical conclusions to those supported directly by underlying documentation.

Finally, some useful data in identifying proliferation risk is not publicly available, such as licenses for the export of controlled goods or purchase requests submitted to nuclear suppliers.[90] Without licensing information in particular, it is seldom possible to definitively determine whether a transaction is illegal. For this reason, this report focuses on identifying risk rather than actual violations of national or international laws and regulations.[91] **Unless explicitly stated, the mention of an individual, company, organization, or other entity in this report is not meant to imply the violation of any law or international agreement and should not be construed to so imply.**

Identifying Illicit Nuclear Procurement in Pakistan

C4ADS found that Pakistan's illicit nuclear procurement networks tend to frequently purchase similar items from the same vendors in a limited number of jurisdictions. With this understanding, we identified 46 previously unknown entities that may also procure on behalf of Pakistan's nuclear program. Based on their trade partners, their locations, and the items they procure, these companies appear likely to acquire foreign-produced equipment for use in unsafeguarded nuclear facilities. We refer to these as "high-risk entities."

C4ADS also identified 33 foreign suppliers that have supplied multiple BIS- or METI-listed entities in Pakistan, many of which are located in the known transshipment hubs of Singapore, Hong Kong, and the UAE. These most central 33 suppliers of Pakistan's known procurement companies are located in mainland China (34%), Hong Kong (18%), the UAE (9%), the United States (9%), Germany (6%), Italy (6%), and Singapore (6%). Hong Kong, the UAE, and Singapore are transshipment hubs, while China, the United States, Germany, and Italy are NSG members.[92, 93, 94] Shipments of nuclear dual-use goods from NSG member states to these companies may be in contravention of NSG guidelines. C4ADS also identified the top suppliers of high-risk entities, an additional 54 foreign companies. These findings support the findings in Project Alpha's 2016 report on Pakistan's nuclear and missile industry, which found at least 20 main providers of Pakistan's strategic industries, located primarily in mainland China, Hong Kong, Dubai, and Singapore.[95]

MAPPING THE EXTENDED PROCUREMENT SYSTEM

FROM KNOWN ENTITIES TO FOREIGN SUPPLIERS

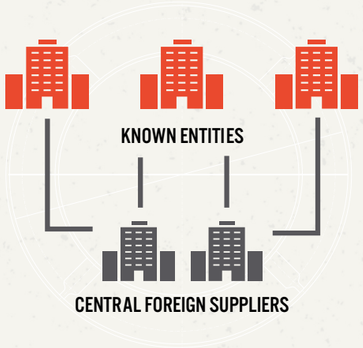
Analysts used Pakistani trade data to identify the trade activity of 55 entities known to have procured for Pakistan's unsafeguarded nuclear facilities. C4ADS defines these companies as "**known entities.**"

C4ADS then built out the known entities' overseas trading activity using trade data, including more than 4 million Pakistani bill of lading-level trade data records spanning over three years of trade. This allowed C4ADS to identify 955 foreign suppliers that have sent shipments to these 55 known entities.

FROM FOREIGN SUPPLIERS TO CENTRAL SUPPLIERS

Analysts then built out the larger trade environment associated with Pakistani procurement by identifying all companies in Pakistan that have purchased from the 955 foreign suppliers of known entities identified above. This larger set included 3,080 total Pakistani and foreign entities connected by a total of 35,872 shipments.

C4ADS then focused in on the subset of trade related to foreign suppliers that provided goods to two or more known entities. We consider these 33 foreign suppliers to be "**central suppliers**" of known entities.

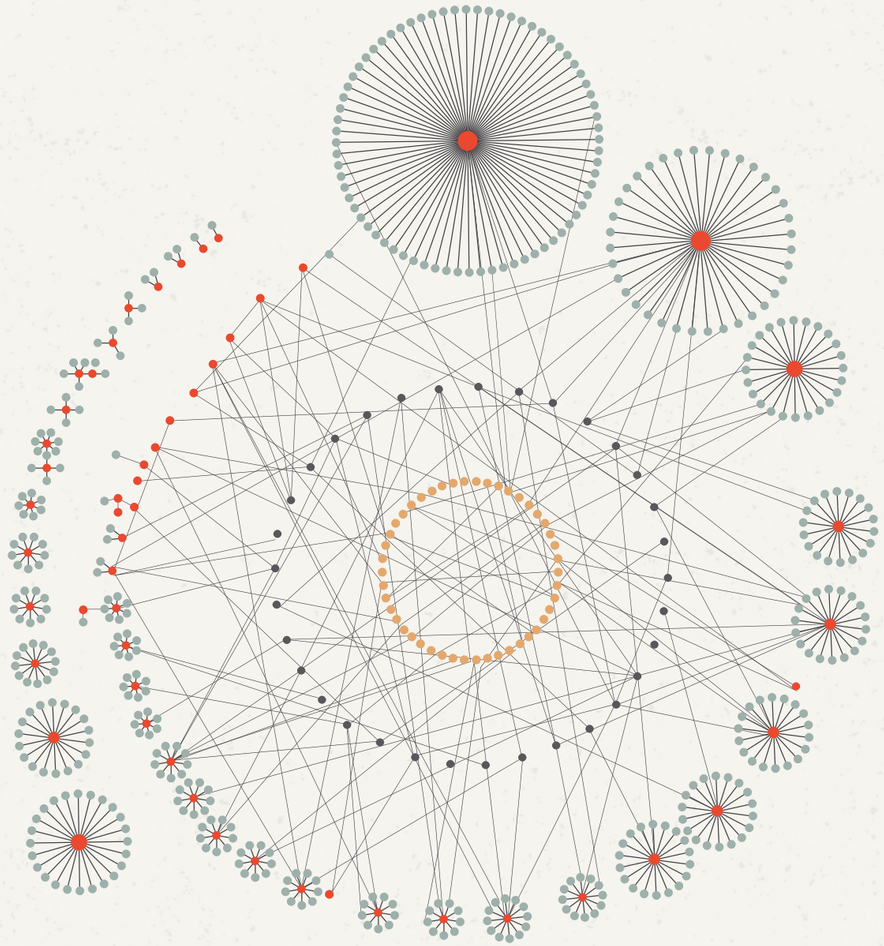


FROM CENTRAL SUPPLIERS TO UNKNOWN HIGH-RISK ENTITIES

To determine how our subset of central suppliers fit into the overall trade proliferation system, C4ADS then analyzed patterns of trade activity of central suppliers, including the products they trade, their addresses, and their associated corporate networks. We focused on their Pakistani counterparties, "**high-risk entities**" in Pakistan that are also purchasing from the central suppliers, but that are not listed by national export control authorities or named in derogatory reporting as linked to the Pakistani nuclear program. Through this method, C4ADS identified 46 high-risk entities which purchase from "central suppliers" – and thus interact with the wider trade networks associated with our list of known entities.

The following graphic illustrates the relationships between the three categories of companies we profiled: **known entities**, their **33 central suppliers**, and the **46 high-risk** Pakistani companies that behave similarly to known entities.

IDENTIFYING HIGH-RISK ENTITIES THROUGH TRADE NETWORK ANALYSIS: PAKISTAN



KNOWN ENTITY
A Pakistani company that has been listed as having procured products for Pakistan's nuclear program.

CENTRAL TRADE PARTNER OF KNOWN ENTITIES
One of 33 foreign companies who have transacted with two or more known Pakistani entity in 2016-2019

TRADE PARTNERS OF KNOWN ENTITY
Suppliers of single known entities. Foreign companies that have sent one or more shipments to only one known entity.

HIGH-RISK ENTITY
A Pakistani company that exhibits elevated risk of procuring for Pakistan's nuclear program, based on their patterns of purchasing from suppliers of known entities.

NUCLEAR DUAL-USE GOODS IN PAKISTAN ↓

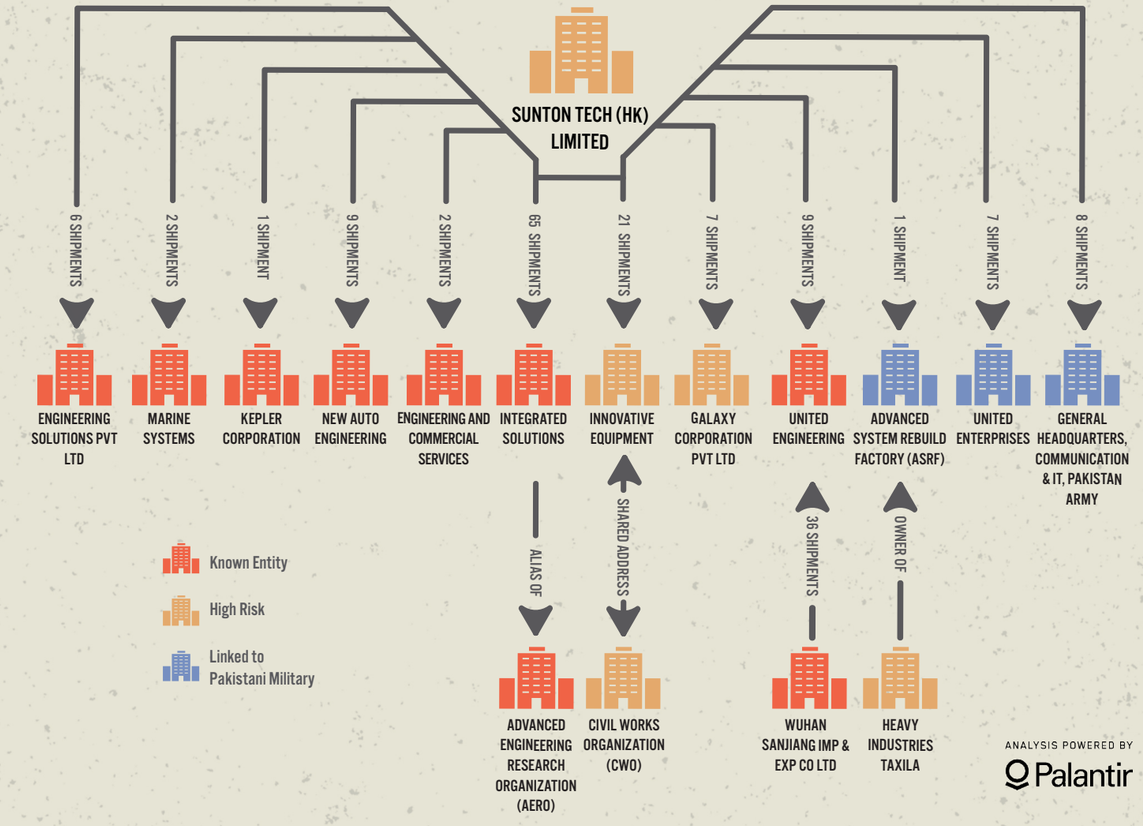
By studying the most significant suppliers of known entities and high-risk entities, C4ADS was able to identify the products they frequently source. These include pressure transmitters, cutting tools and milling machines, frequency inverters, graphite powder, valves, and other metal products. Previously unidentified high-risk companies that bought from the same suppliers also frequently purchased these items. Some of these products may be export controlled nuclear dual-use goods under Nuclear Suppliers Group guidelines and national export control regulations. It is not possible to positively determine whether these goods are nuclear dual-use because product descriptions in trade data lack the specificity of export control regimes. However, some shipments contained products, like "electronic connectors," that Pakistani companies have previously illicitly acquired from the United States for organizations including the Pakistan Atomic Energy Commission (PAEC). [96]

FOREIGN SUPPLY CHAIN — TRANSSHIPMENT HUBS AND TRANSNATIONAL PROCUREMENT NETWORKS

On the theory that our high-risk entities could be part of wider procurement networks, C4ADS used the same methodology to identify the most central suppliers of the **high-risk entities** from the earlier section. This second-order analysis yielded an additional 54 foreign companies. By comparing them with the original **33 central suppliers** of our **known entities**, we can assess how closely intertwined the trading networks of known and unknown high-risk Pakistani proliferators are, and what characteristics are shared in their trade activity.

- **The 54 most central suppliers of high-risk entities are often located in the same jurisdictions as central suppliers of known entities:** 39% are based in mainland China, 11% in Hong Kong, 10% in the United Arab Emirates (UAE), 5% in Singapore, and 5% in Italy. This geographic distribution of central suppliers of high-risk entities reflects the distribution of the top suppliers of known entities, as well as the concentration of significant suppliers in transshipment hubs like Hong Kong, the UAE, and Singapore.[97]
- **In the UAE, central suppliers are frequently located in free trade zones.** Free trade zones are duty-free areas that offer facilitated trade but are vulnerable to illicit trade due to their lack of transparency.[98, 99, 100] Sixty percent of the most central suppliers located in the UAE are registered in free trade zones, and at least three of these companies appear to be connected through personnel and identifiers to high-risk entities in Pakistan. Consequently, these companies may be controlled by entities in Pakistan, and may be acting on behalf of Pakistan's strategic industries.
- **In Hong Kong, supply chains for known entities and high-risk entities appear to be highly concentrated.** Only about 1.5% of shipments to known entities and high-risk entities were sent by Hong Kong companies, but these companies are much more likely to supply multiple listed entities. Of the shipments sent by Hong Kong-based companies to known and high-risk entities, 73% were sent by companies that C4ADS identified among the 86 most central suppliers.
- **Some central suppliers in Hong Kong and the UAE appear to be controlled by entities in Pakistan and may be acting on behalf of Pakistan's strategic industries.** This is indicated by an analysis of their trade with Pakistan, which almost exclusively serves high-risk companies, known entities, and military enterprises, and analysis of their corporate networks, which indicate ownership by Pakistan entities. This report explores one such case in Hong Kong, involving **Sunton Tech (HK) Ltd**, while a C4ADS blog post examines a similar case in UAE, involving **Pegasus General Trading FZE**.[101] This finding is consistent with US BIS listings and US law enforcement actions directed at UAE and Hong Kong entities supporting Pakistan's nuclear and missile programs, as well as with 2016 findings by Project Alpha.[102, 103, 104]

SUNTON TECH: UNIDENTIFIED HIGH-RISK SUPPLIER



Sunton Tech (HK) Limited is a company in Hong Kong that advertises the sale of electronics and communication system components.[105] The company is not listed as a proliferation concern by any national authorities, and it has not previously been publicly reported as having any association with Pakistan's nuclear or missile programs. However, trade data indicates that Sunton Tech is one of 33 companies globally and 6 companies in Hong Kong that have supplied two or more BIS-listed entities in Pakistan. In fact, according to available trade data, Sunton Tech is a supplier of at least seven BIS- listed entities in Pakistan and has additionally sought to procure technology with nuclear and/or missile applications from a US company as recently as 2017.

SUPPLYING BIS-LISTED COMPANIES

Trade data indicates that Sunton Tech regularly supplies companies which are reported to procure for Pakistan's nuclear and missile programs. This trade data indicates that, in 2016 and 2017, Sunton Tech sent at least 60 shipments to Integrated Solutions, which is a known alias of Advanced Engineering Research Organization (AERO).[106] AERO has been listed by BIS since 18 September 2014 for its involvement in the illicit procurement of sensitive technology in support of Pakistan's missile and strategic unmanned aerial vehicle programs.[107]

Between 29 December 2015 and 23 May 2019, Sunton Tech is also reported in trade data to have sent 23 shipments to Kepler Corporation, United Engineering, Engineering and Commercial Services, Marine Systems Pvt. Ltd, New Auto Engineering, and Engineering Solutions Pvt. Ltd. BIS listed all of these companies between December 2016 and March 2020 for offenses relating to illicit procurement of sensitive technology or "actions contrary to the national security or foreign policy interests of the United States."[108, 109]

Sunton Tech also sent shipments, as reported in available trade data, to the Pakistani company **United Engineering** (United Engineering was added to the BIS Entity List on 16 March 2020 for contributing Pakistan's missile program*), which has transacted with entities designated by the US Department of the Treasury's Office of Foreign Assets Control (OFAC) for proliferation activities relating to Iran and North Korea.[113, 114] United Engineering received at least six shipments in the past five years from **Wuhan Sanjiang Import and Export Co. Ltd.**, which OFAC designated in November 2017 for supporting Iranian proliferation activities.[115] According to OFAC and the United Nations Panel of Experts on North Korea, Wuhan Sanjiang also supplied North Korea with four WS51200 vehicles, which were used as transporter-erector-launchers (TELs) for North Korea's Hwasong-13 and Hwasong-14 intercontinental ballistic missiles.[116, 117]

SUPPLYING HIGH-RISK COMPANIES

According to trade records, Sunton Tech has also sent shipments to two of the 46 high-risk Pakistani companies not on national export control lists that were identified by C4ADS. For example, these trade records indicate that Sunton Tech sent at least ten shipments to a Pakistani company called **Innovative Equipment**, some as recently as August 2019. The trade records also indicate that Innovative Equipment listed an address shared by the **Civil Works Organization** (CWO). The CWO has been reported to have acted as a procurement agent for **Khan Research Laboratories** (KRL), according to the verdict of a 1993 German court case. This case resulted in the conviction of two individuals who had illegally transferred equipment for KRL's isotope separation plant in Pakistan.[110, 111] KRL has been listed by BIS since 1998 for its role in Pakistan's nuclear weapons program.[112]

According to customs records, Sunton Tech also sent shipments of electronics to **Galaxy Corporation** in December 2017. Project Alpha at King's College London identified Galaxy Corporation as a probable front company for the Pakistan Atomic Energy Commission (PAEC) in 2016.[118]

SUPPLYING MILITARY-LINKED COMPANIES

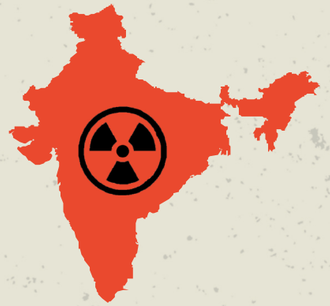
Sunton Tech has also supplied at least two entities affiliated with the Pakistani military. For example, in the past three years, trade records indicate that Sunton Tech sent four shipments to **United Enterprises**, which lists the Pakistani military as one of its key customers on its website.[119] One of these shipments has the HS code 930190, which corresponds with military weapons, including automatic firearms.[120] Additionally, according to customs records, Sunton Tech sent at least one shipment of electronic components to the Advanced System Rebuild Factory (ASRF). ASRF is a subsidiary of Heavy Industries Taxila, which produces gun control systems and other electronics for tanks and armored personnel carriers.[121]

PROCUREMENT OF SENSITIVE TECHNOLOGY FROM THE UNITED STATES

Sunton Tech reportedly sought to acquire goods from a New York-based company whose products have application in missiles, torpedoes, and aircraft, and which has supplied other high-risk companies. Publicly available information indicates that Sunton Tech attempted to procure 10 dual axis inclinometers from this US-based manufacturer in 2017.[122] dual-axis inclinometers have applications in gravity reference for missiles, torpedoes, antennae, and manufacturing equipment.[123] According to trade data, the aforementioned Pakistani company Galaxy Corporation, which Project Alpha identified as a probably front company for PAEC, received shipments of sensors and other unknown products from this same New York-based company in July 2017.

*https://www.federalregister.gov/documents/2020/03/16/2020-03157/addition-of-entities-to-the-entity-list-and-revision-of-entry-on-the-entity-list

Procurement for Unsafeguarded Facilities in India

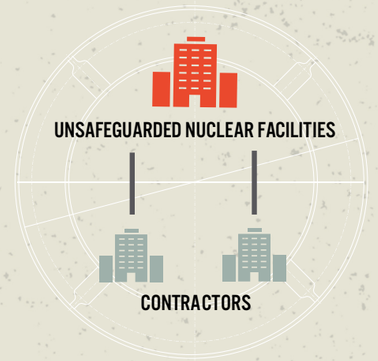


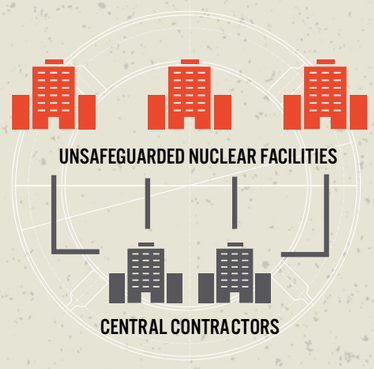
India relies on private contractors to procure goods for use in unsafeguarded nuclear facilities, which are not subject to IAEA verification. These contractors import primarily from a small group of countries, including Germany, China, and the United States — all NSG member states.

C4ADS analyzed tenders for Indian nuclear facilities and identified **86 companies** that procured products or conducted works at two or more unsafeguarded nuclear facilities. Transactions involving contractors for unsafeguarded nuclear facilities are not necessarily illicit, particularly given India's status in the global nuclear community.[124, 125] These findings, however, provide context for monitoring and verification agreements by providing an ecosystem picture of the states and foreign companies that are most exposed to procurement for unsafeguarded Indian civilian and military nuclear facilities.

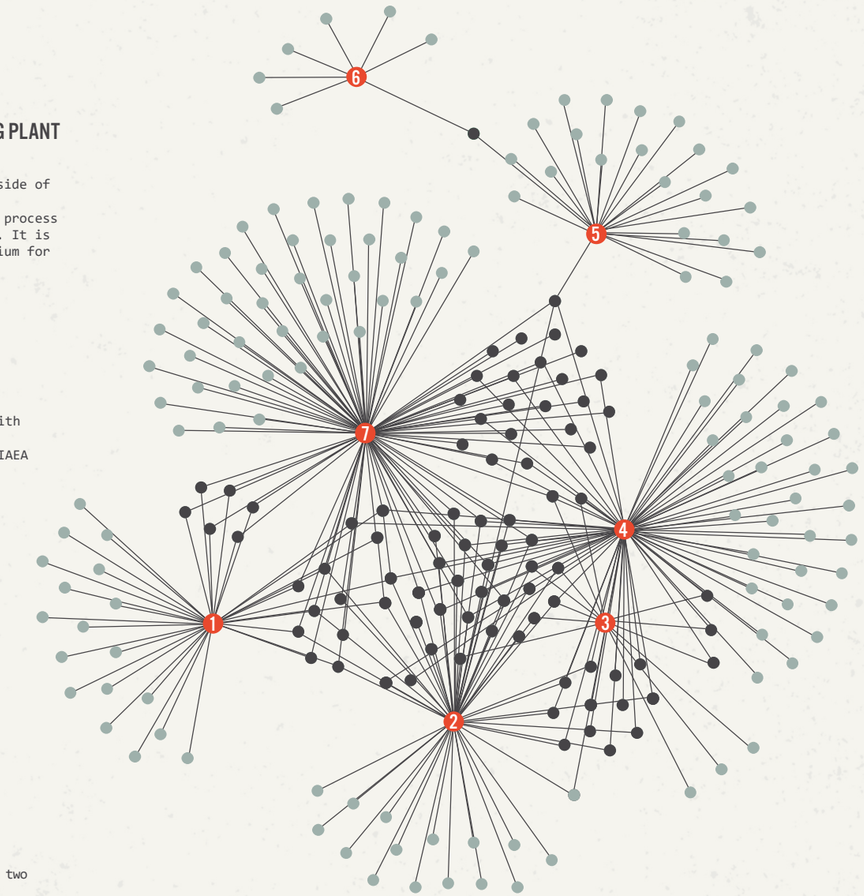
MAPPING THE EXTENDED PROCUREMENT SYSTEM

There are no publicly available lists of entities procuring for India's nuclear program, and there are few restricted end users in India.[126] Instead, C4ADS used more than 40,000 publicly available tender records to map Indian companies involved in nuclear procurement. These records contain information on specific companies that have procured material for specific facilities, allowing analysts to distinguish between companies servicing unsafeguarded civilian and military facilities from the larger nuclear technology procurement apparatus.[127,128,129] We used these records to generate a list of 222 companies that contract for seven known unsafeguarded facilities in India. Of these, 86 companies contracted with two or more unsafeguarded nuclear facilities.





IDENTIFYING HIGH-RISK ENTITIES THROUGH PUBLICLY AVAILABLE INFORMATION: INDIA



1

KALPAKKAM ATOMIC REPROCESSING PLANT (KARP)

A civilian reprocessing facility outside of IAEA safeguards. KARP uses the plutonium-uranium extraction (PUREX) process to produce plutonium from spent fuel. It is unclear whether KARP provides plutonium for India's nuclear weapons program.

Supplied by 34 Contractors

2

KAIGA GENERATING STATION (KGS)

A civilian power reactor facility, with four Pressurized Heavy Water Power Reactors (PHWRs) that are not under IAEA safeguards.

Supplied by 65 Contractors

3

KAKRAPAR ATOMIC POWER STATION (KAPS)

A civilian power reactor facility, with two Pressurized Heavy Water Power Reactors (PHWRs) that are not under IAEA safeguards.

Supplied by 22 Contractors

4

TARAPUR ATOMIC POWER STATION (TAPS) UNITS 3 AND 4

A civilian power reactor facility, with two Pressurized Heavy Water Power Reactors (PHWRs) that are not under IAEA safeguards. Another two PHWRs at this facility are under safeguards (units 1 and 2).

Supplied by 100 Contractors

5

BHABHA ATOMIC RESEARCH CENTER (BARC)

A research center housing centrifuge enrichment facilities, research reactors, and fuel reprocessing. Some enrichment and reprocessing at BARC produces weapons grad eplutonium and highly enriched uranium for either naval fuel or nuclear weapons. BARC is one of the only Indian nuclear entities listed by the US Department of Commerce Entity List.

Supplied by 21 Contractors

6

RARE MATERIALS PLANT (RMP)

A gas-centrifuge plant that produces highly enriched uranium for naval reactor fuel. RMP may produce uranium for use in nuclear weapons.

Supplied by 7 Contractors

7

MADRAS ATOMIC POWER STATION (MAPS)

A civilian power reactor facility, with two Pressurized Heavy Water Power Reactors (PHWRs) that are not under IAEA safeguards. Spent fuel from MAPS has been reprocessed to produce plutonium that could be used in nuclear weapons.

Supplied by 108 Contractors

CONTRACTOR

Indian company that has received contracts to procure goods or provide services at one unsafeguarded nuclear facility.

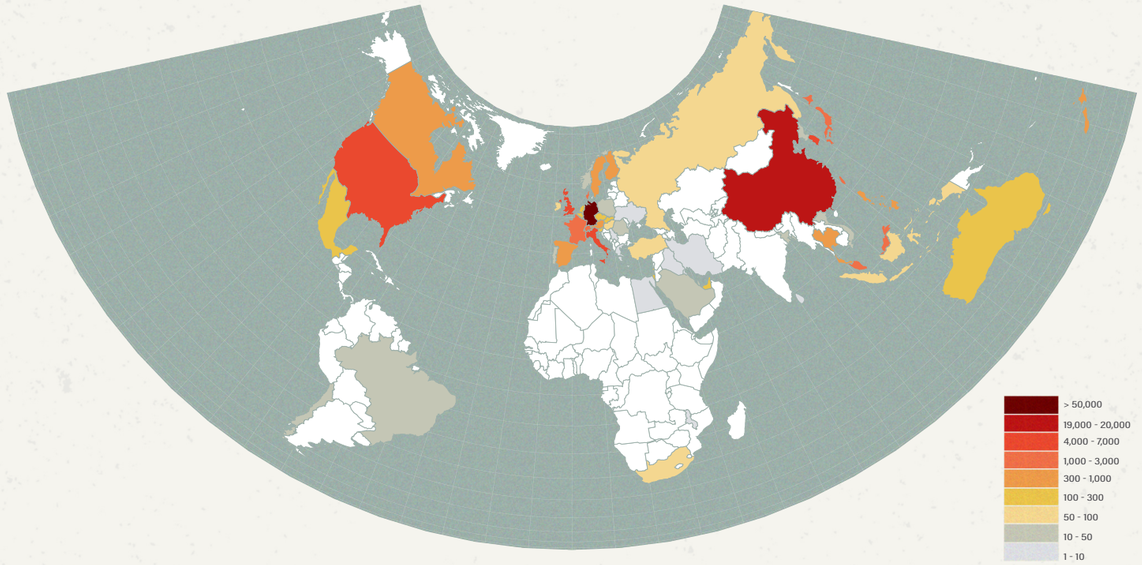
There are 222 contractors supplying at least 1 unsafeguarded facility

CENTRAL CONTRACTOR

Indian company that has received contracts to procure goods or provide services for two or more unsafeguarded facilities.

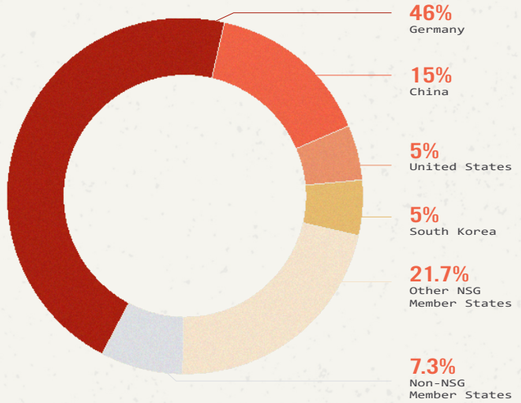
There are 86 contractors supplying at least 2 unsafeguarded facilities

TOP ORIGIN COUNTRIES, BY VOLUME, FOR PRODUCTS SHIPPED TO CONTRACTORS OF INDIAN UNSAFEGUARDED FACILITIES January 2017 – July 2019



FOREIGN SUPPLY CHAIN — NUCLEAR SUPPLIERS GROUP

As noted above, Indian procurement tenders showed 86 companies servicing two or more unsafeguarded facilities. According to trade data available to C4ADS, these 86 companies received 124,089 imports from 64 countries between January 2017 and July 2019. The top origin countries for these shipments were Germany, China, and the United States.[130] Of the total imports to these 86 companies, 46% were from Germany, 15% from China, 5% from the US, and 5% from South Korea. All of these countries are members of the Nuclear Suppliers Group (NSG).[131] All told, 92.7% of exports to these 86 companies originated from companies in NSG member states.

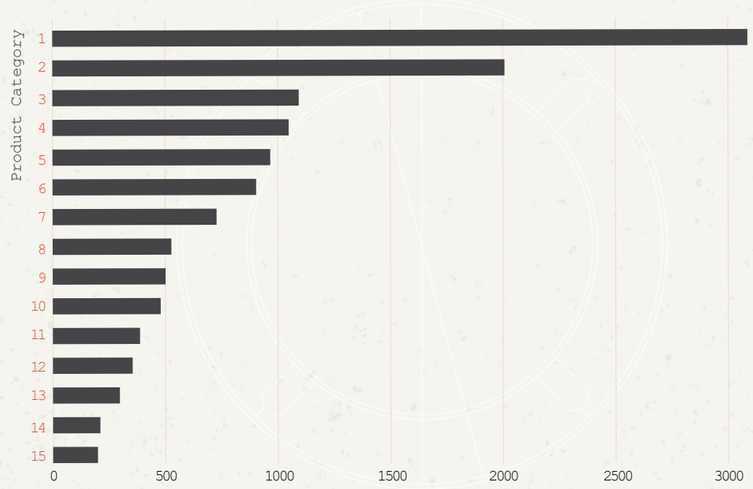


The top origin countries, by number of shipments, are Germany, China, United States, South Korea, and the UK

Russia does not appear in the list of top origin countries for shipments to the Indian companies that service two or more unsafeguarded facilities, even though historically Russia has been one of the top suppliers of nuclear dual-use goods to India.[132] This is because, as indicated in trade data, most transfers from Russian nuclear suppliers were directly from Russian companies to Indian state-owned corporations such as the Nuclear Power Corporation of India Limited (NPCIL) rather than to the contractors which were the subject of this test case.[133] According to trade data, these Russian-supplied products are largely intended for use in the Kudankulam Nuclear Power Plant, a safeguarded nuclear facility constructed by a partnership between NPCIL and Russia's state-owned nuclear company, Rosatom.[134] NPCIL does oversee unsafeguarded facilities, however, so there is a risk that products sent from Russia to NPCIL could be diverted to unsafeguarded fuel cycle activities.[135]

Eight percent of trade to the 86 Indian companies servicing two or more unsafeguarded is associated with HS codes that correlate with export control lists published by the Nuclear Suppliers Group and the European Union.[136, 137] To isolate these shipments, we generated a correlation table matching HS codes to the Nuclear Suppliers Group Guidelines' definitions of nuclear direct-use and dual-use goods.[138, 139] We then filtered the exports from companies in NSG member countries to the list of 86 companies by these HS codes.[140] HS codes that flagged these shipments correspond to dual-use goods including carbon fiber, power supplies, specialized valves, maraging steel, machine tools, and non-destructive testing equipment.

TOP NSG-CORRELATED HS CODES IN TRADE FROM NSG MEMBER STATES TO INDIAN SUPPLIERS OF UNSAFEGUARDED FACILITIES



1 CARBON FIBRE & FILAMENTARY MATERIALS
2 POWER SUPPLIES, HIGH CURRENT
3 VALVES, BELLOWS
4 MACHINE TOOL MOTION CONTROL BOARDS
5 CHAMBERS, AEROSOL CHALLENGE TESTING
6 MARAGING STEEL
7 NON-DESTRUCTIVE TEST (NDT) EQUIPMENT, 3 DIMENSIONAL
8 PROPELLANT PRODUCTION EQUIPMENT
9 SWEPT FREQUENCY NETWORK ANALYSERS
10 PROPULSION SYSTEM COMPOSITE COMPONENTS/STRUCTURES
11 PULSE GENERATORS, FOR DETONATORS
12 END EFFECTORS, ROBOT
13 RING GYROS (LASER) & GYRO COMPONENTS
14 COMPRESSORS; OF A KIND USED IN REFRIGERATING EQUIPMENT||UNDER GARMENTS KNITTED, NOT ELAST. NOR RUBBERD
15 INERTIAL NAVIGATION SYSTEMS INTEGRATION SOFTWARE

Filtering these shipments by NSG-correlated HS codes also illustrated which NSG member countries sent the highest volume of shipments with these HS codes: Germany (35%), China (13%), the United States (12%), and South Korea (9%). Verifying that these shipments actually contain export-controlled nuclear dual-use goods or other sensitive technology requires manual review of each record.[141] While this level of granularity was not possible for C4ADS in the project timeframe, this deductive process — identifying trade to known suppliers of unsafeguarded nuclear facilities, from NSG member states, containing HS codes that are associated with NSG-controlled products — allowed us to isolate the trade that represents the highest risk and the countries most exposed to it.

RARE MATERIALS PLANT: MONITORING CONTRACTORS SERVICING A MILITARY NUCLEAR FACILITY

India's Department of Atomic Energy maintains a uranium enrichment facility in Rattehalli, India, known as the Rattehalli Rare Materials Plant (RMP), which is outside of IAEA safeguards.[142, 143] The RMP operates a gas centrifuge plant, which produces highly enriched uranium that could be used as naval fuel or in nuclear weapons.[144] Observers have raised concerns over the construction of a new centrifuge hall at RMP, which was completed in 2016.[145] This expansion could augment India's ability to enrich uranium for nuclear weapons.[146]

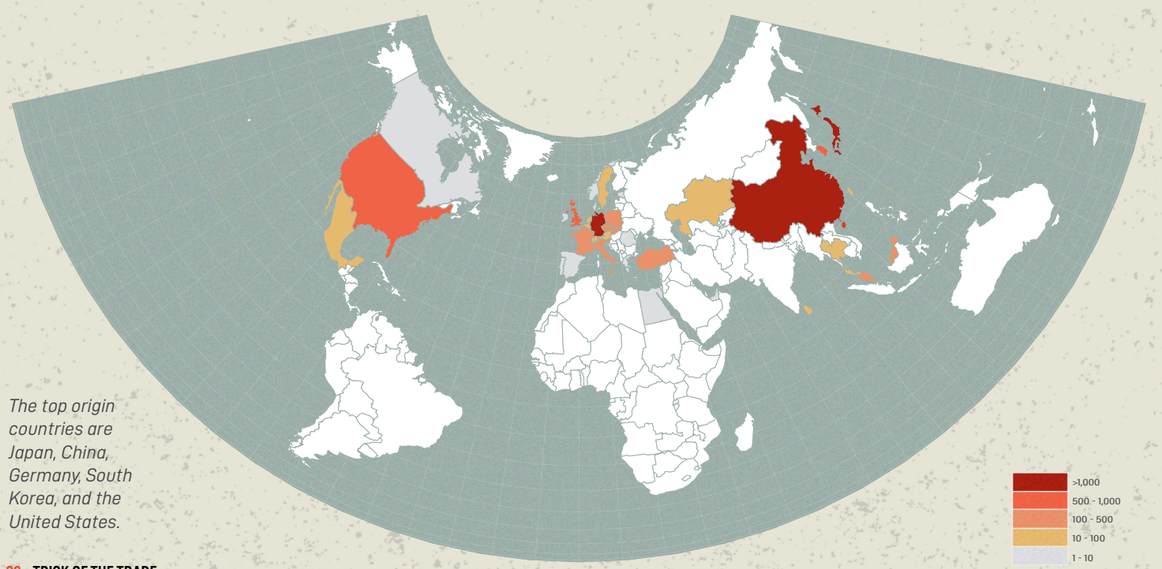
C4ADS identified seven contractors that have procured materials for RMP. Some of the products they procured may be nuclear dual-use goods and include items such as spring-energized metal seals, pressure transducers, furnace systems, valves, vacuum pumps, mass spectrometers, and more.[147] For each of these companies, analysts then used trade data to map the foreign trade partners that most frequently supply these contractors. While researchers have investigated construction at RMP with satellite imagery, there is little publicly available information about how and from whom India procures material and technology used at RMP.[148, 149] Trade data and tender shed light on which companies are most likely to procure items for RMP, and where they tend to source items from abroad.

IMPORTS BY RMP CONTRACTORS

Between January 2017 and July 2019, these seven companies imported 8,478 shipments primarily comprised of chemicals, vacuum pumps, compressors, and other industrial goods valued at approximately $51,147,820. The total value of the RMP purchase orders awarded to these companies, however, was only $1,501,869, suggesting that these contracts make up only a small proportion of these seven companies' total business in India.

The top origin countries for products shipped to the seven RMP contractors between January 2017 to July 2019 are Japan (17%), China (16%), Germany (13%), South Korea (11%), and the United States (7%).[150, 151] All of these countries are members of the Nuclear Suppliers Group.[152]

MAP OF TOP ORIGIN COUNTRIES, BY VOLUME, FOR PRODUCTS SHIPPED TO RMP CONTRACTORS
January 2017-July 2019



The top origin countries are Japan, China, Germany, South Korea, and the United States.

Foreign companies transferring nuclear dual-use goods to contractors for unsafeguarded facilities like RMP expose themselves to the risk of diversion. Because unsafeguarded facilities in India procure technology and materials through contractors, it is possible that foreign suppliers of these products are not aware of their ultimate end use, a pattern previously observed in India's procurement of nuclear technology.[153] Though this pattern of procurement can obfuscate the end users of nuclear technology, activity-based analysis allows for the assessment of the risk posed by specific companies and the exposure of specific foreign countries to this risk.

NUCLEAR DUAL-USE GOODS IN INDIA ↓

Combining trade data with tenders allows analysts to trace a possible path of a good from abroad to a nuclear facility. For example, C4ADS used trade data to identify 9 transfers of nuclear-grade graphite gaskets from China to one Indian company in 2018. Alone, this detail would not be significant, given that the majority of modern graphite is nuclear-grade.[154, 155] However, as is visible in tenders, this same company also received 25 procurement orders for gaskets for Indian nuclear facilities between 2015 and 2019, nine of which specify that the gaskets be graphite-filled. These procurement orders specify that the gaskets are for use in unsafeguarded nuclear facilities including Tarapur Atomic Power Station power units 3 and 4, and Kaiga Generating Station.[156, 157] Though it is difficult to definitely confirm that the gaskets from China were used in unsafeguarded Indian nuclear facilities, pairing these data sources demonstrates a risk in these transactions that may not have otherwise been understood to be risky.

Conclusion:

Strengthening Societal Verification for Proliferation Monitoring

Pakistan and India's nuclear weapons programs pose a threat to regional and global security.[158] As we document in this report, these networks are larger and more visible than previously publicly reported. They remain active and continue to procure nuclear dual-use goods from abroad for potential use in unsafeguarded facilities or nuclear weapons programs. This report demonstrates how publicly available information (PAI) can be used to map these networks to facilitate compliance and enforcement of nonproliferation regimes.

We believe our findings have particular relevance for private sector companies, national export control authorities, and multinational organizations, who are at the frontlines of nonproliferation compliance. We assess that the supply chains of nuclear technology procurement networks in Pakistan and India are visible in PAI, and therefore vulnerable to enhanced risk screening and enforcement action. Methodologies using PAI and activity-based analysis can equip stakeholders to better identify and understand not just national, but also entity-level, exposure to procurement activities that may benefit a nuclear weapons program. In the enforcement context, at least some of the transfers and networks identified by C4ADS could constitute violations of national export control regulations or contravene NSG guidelines,[159] though conclusive identification will require further investigation by relevant empowered institutions.

More specifically, our findings provide important typologies that may help inform enhanced due diligence and societal verification efforts for South Asian nuclear proliferation.

- Nuclear technology procurement networks behave differently in Pakistan and India.[160] The Pakistani procurement system relies on key foreign suppliers that trade with both listed entities and high-risk entities that are not listed. In India, unsafeguarded nuclear facilities rely on a set of at least 222 contractors to procure materials from abroad.
- Commonly used transshipment hubs for North Korean and Iranian proliferation activity (as documented in other C4ADS reports[161]) also are extensively used by Pakistani companies at risk of engaging in illicit procurement. Companies in these territories, including Hong Kong, the UAE, and Singapore, make up 33% of the most central suppliers to known entities and high-risk companies in Pakistan.
- Indian companies that exhibit risk of supplying unsafeguarded facilities tend to procure directly from NSG member states. Ninety-two percent of shipments to Indian companies that have procured for two or more Indian unsafeguarded facilities originated from companies in NSG member states. This may reflect the impact of India's NSG waiver and the general assessment of lower due diligence risk.[162]
- Both Pakistan and India share a reliance on China-based suppliers — Chinese companies make up 52% of the most central suppliers of Pakistan known entities and high-risk companies and 15% of the volume of shipments to Indian companies that exhibit risk of supplying unsafeguarded facilities.

Pakistan and India will likely continue their efforts to grow and modernize their nuclear programs. Enhanced due diligence and societal verification must make better use of publicly available information and activity-based analysis to better identify, monitor, and disrupt illicit nuclear procurement networks.

NOTES

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162 It is not possible to determine that the NSG waiver is directly responsible for India's trade with NSG member states. A study of trade data prior to and following the awarding of the waiver might yield results indicating its relative impact.