Nuclear Nonproliferation Export Controls and Dual Use: A Crash Course

Alex Hagen[1]

[1] *Purdue University*

Invited Presentation

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Front Matter: Objectives of this Presentation

⇒ To motivate and describe export controls pertaining to dual use items in nuclear nonproliferation

⇒ To illuminate issues in the modern nuclear dual use export controls from a US-centric viewpoint

⇒ To describe differences and problem points between international and state internal export controls

Front Matter: Resume

Education

PhDNE - Purdue University - Soon
MSNE - Purdue University - August 2014
BSNE - Purdue University - May 2012

Research Experience

⇒ Graduate Researcher at Metastable Fluids Research Laboratory

→ Worked with radiation transport, Neutron generator physics, Linac physics, Thermal-fluidic detection mechanism, Acoustic finite element modeling

⇒ Design Consultant for Sagamore Adams Laboratory

→ Physical Design of rotordynamic systems, Robustness and vibration testing, Export and ruggedization

⇒ Laboratory Intern with NEAMES project at Argonne National Laboratory

→ Reactor Physics, Validation and Verification, leadership computing

Front Matter: Sourcebook

United States Office of Technology Assessment. Technologies Underlying Weapons of Mass Destruction. Technical report, U.S. Government Printing Office, Washington, D.C., 1993

United States Office of Technology Assessment. Export Controls and Nonproliferation Policy. Technical report, U.S. Government Printing Office, Washington, D.C., 1994

Peter Crail. Implementing UN Security Council Resolution 1540. *The Nonproliferation Review*, 13(2):355–399, jul 2006

Douglas M. Stinnett, Bryan R. Early, Cale Horne, and Johannes Karreth. Complying by Denying: Explaining Why States Develop Nonproliferation Export Controls. *International Studies Perspectives*, 12(3):308–326, aug 2011

Jason Harris. Personal Correspondence on Dual Use Export Controls for Nuclear Nonproliferation, 2017

Hamed Alavi and Tatsiana Khamichonak. EU and US Export Control Regimes for Dual Use Goods: an Overview of Existing Frameworks. *Romanian Journal of European Affairs*, 17(1), 2017

Motivation: Proliferation

⇒ The first nuclear nonproliferation concerns were raised before a nuclear weapon was ever created [8]

⇒ Bertrand Russel (a famous pacifist) proposed a premptive strike against the Soviet Union to stop any chance of proliferation [9]

> "That was the twentieth century's task, get through what was inevitably going to come if you go into a technological civilization: which is the ability to blow yourself away - directly, with weapons."
>
> *Gwynne Dyer [7]*

> "...the Capitalist West would sell... ...the rope with which to hang it"
>
> *Vladimir Lenin [6]*

Motivation: Modern Nuclear Dangers

Modern State Enemies

⇒ The top three of Matthew Bunn's nuclear issues facing the new president are nuclear nonproliferation failure stories [10]

→ North Korea

→ Iran

→ An "Unknown" nuclear opponent

Nuclear Terrorism

⇒ Nuclear Terrorism is one of this century's grand challenges [11]

⇒ The UN passed Council Resolution 1540 to specifically and universally enact preventative measures from non-state actors attaining nuclear weapons of mass destruction [3]

Balance

⇒ Global trade is larger than ever before, and any limiting factor will be increasingly resisted

⇒ The comparative technology complexity difference between everyday life and that required to make nuclear weapons is ever decreasing

Nonproliferation and Export Controls: Nonproliferation - A hierarchical view

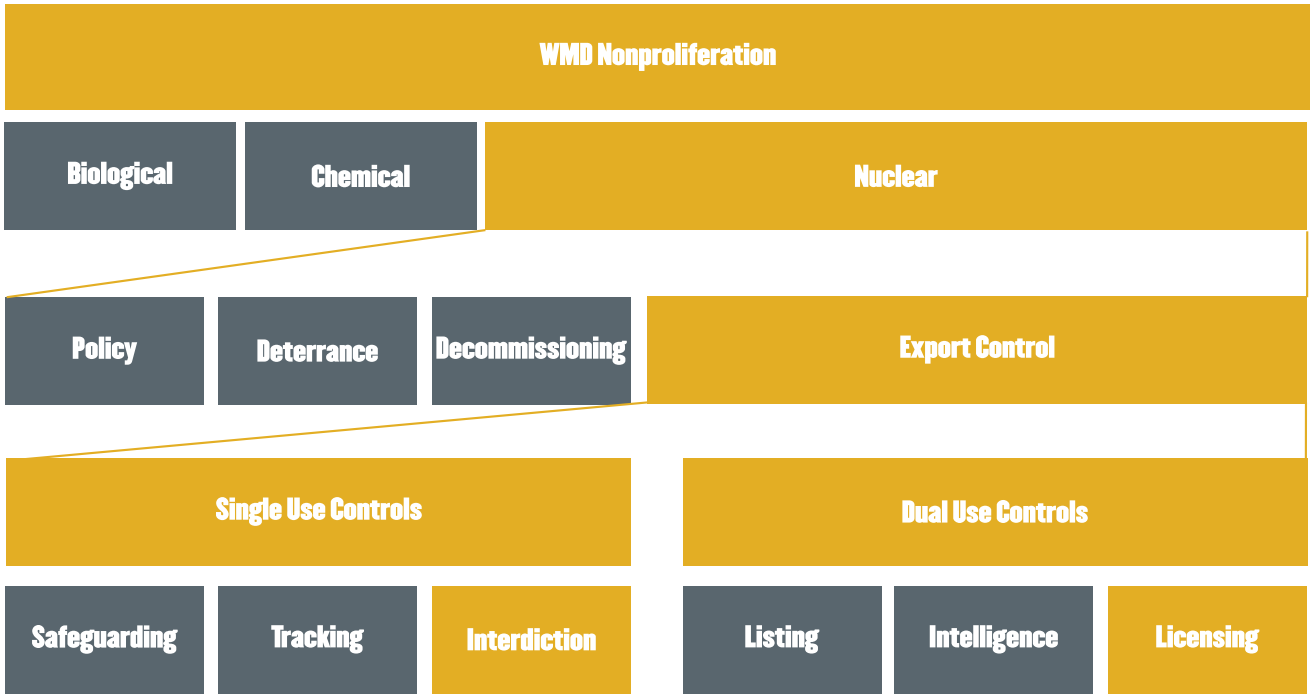

Figure 1: Hierarchical View of Nonproliferation

Nonproliferation and Export Controls: Dual Use

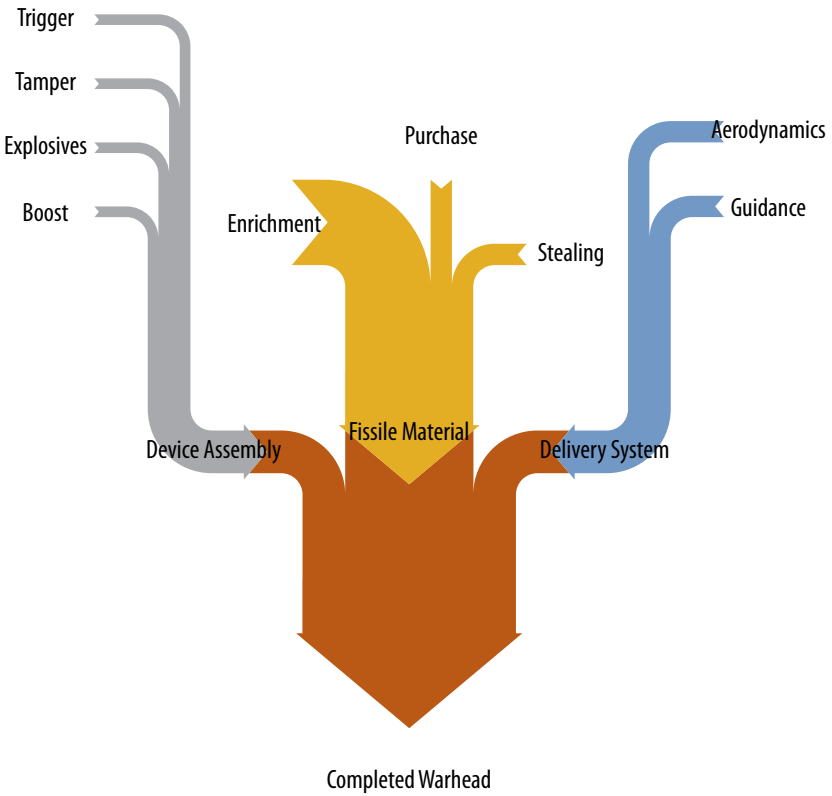

Figure 2: Schematic representation of research, development, and assembly of a nuclear weapon

⇒ Dual Use Items include [1]

- → A Nuclear Reactor
- → Neutron Generators
- → Lowly Enriched Uranium
- → High Explosives
- → Explosive shaping isostatic presses
- → Maraging Steel
- → High Precision CNC Lathes
- → Beryllium*, Hafnium, Zirconium
- → Valves
- → Lasers
- → Supercomputers

Nonproliferation and Export Controls: Proliferation - A Global Issue

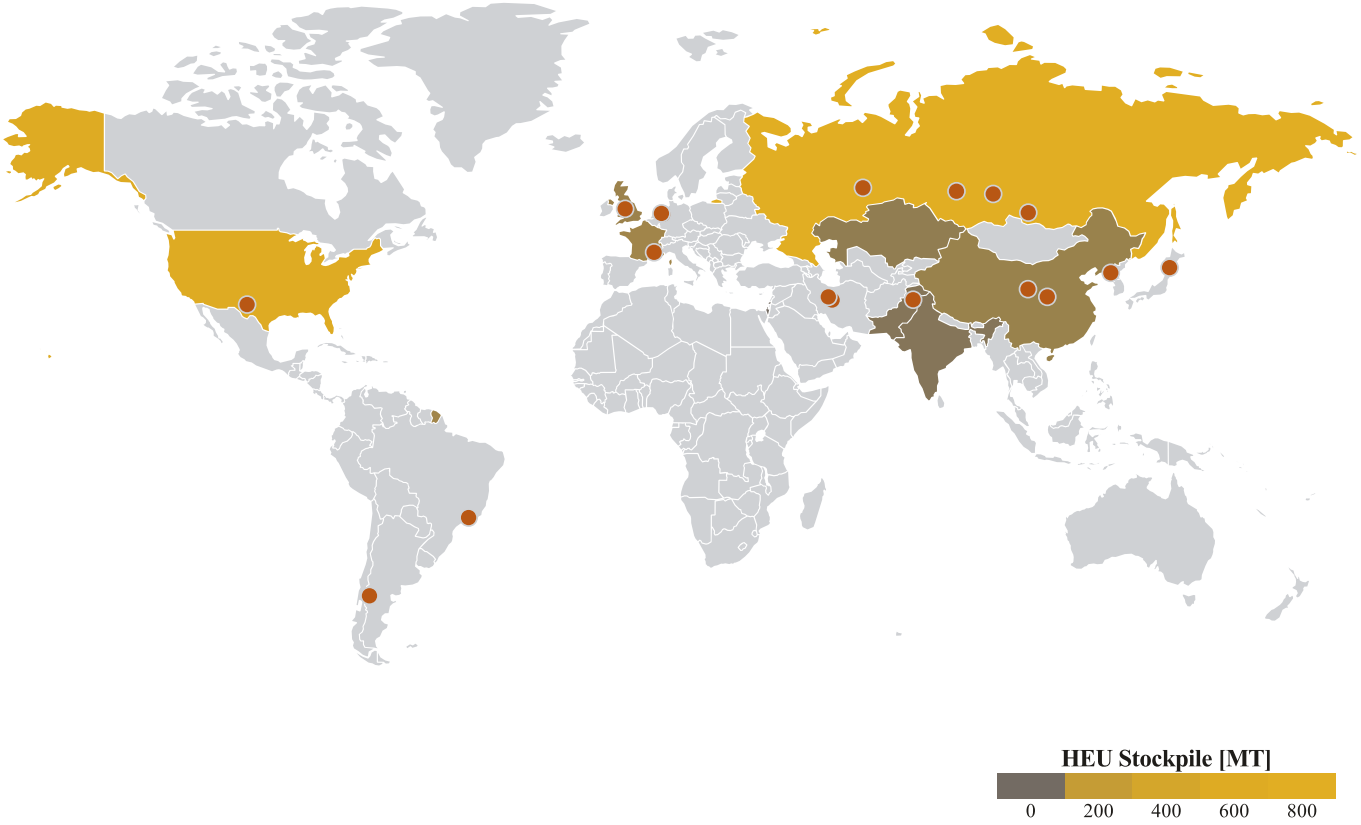

Figure 3: Map of HEU stockpiles and processing plants

Failures of Nonproliferation: Timeline of Proliferation

⇒ Six countries attained warheads before the NPT (1968)

⇒ Four attained warheads after the NPT, only one (South Africa) no longer has them

⇒ Three attained warheads because of the fall of the U.S.S.R. and subsequently returned them [12]

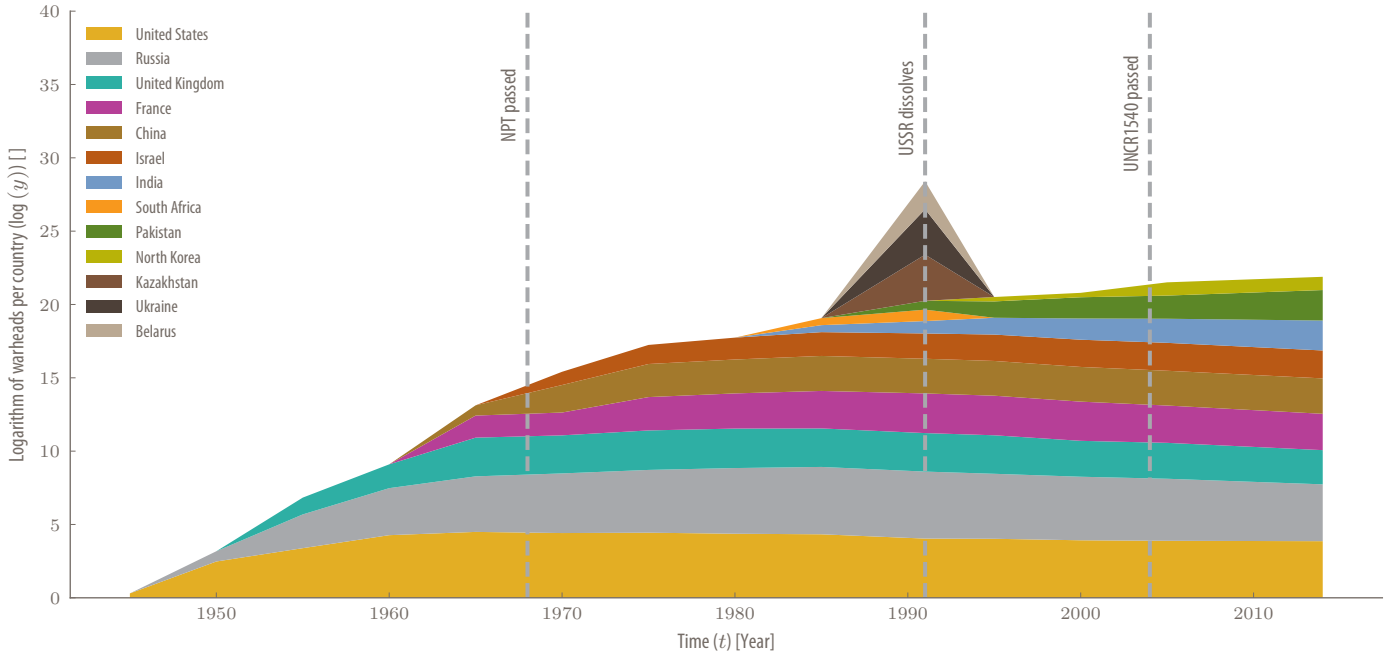

Figure 4: Logarithmic (per country) count of warheads per country throughout time with some important events indicated [12]

Failures of Nonproliferation: A.Q. Khan's Proliferation Network

⇒ A.Q. Khan's proliferation network almost single handedly proliferated nuclear weapons to many states and some non-state actors

⇒ Showed ability of non nuclear states to still develop technology without the expertise to perform export controls [13]

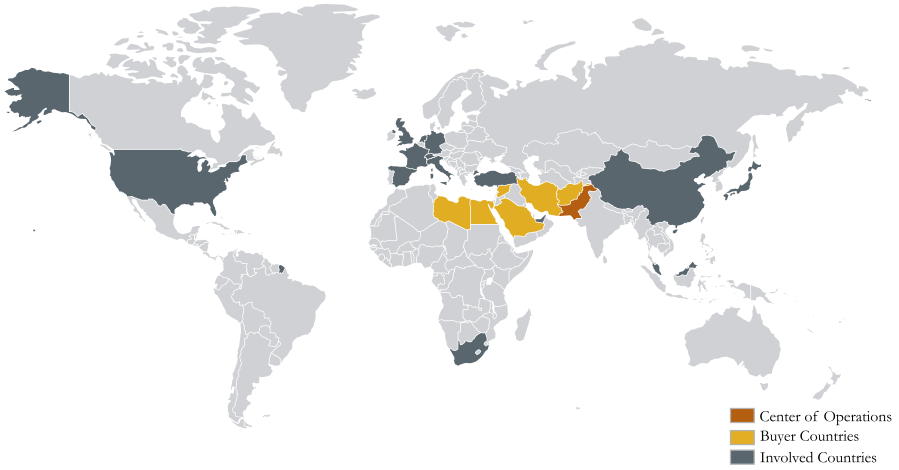

Figure 5: Map of A.Q. Khan's Influence

Problems with Current Export Controls: Arsenal versus Bomb

Proliferation of a Nuclear Arsenal

⇒ Requires a large infrastructure and monetary investment

⇒ More likely to be an end-goal for state actors

⇒ Detection of activities related to nuclear arsenal attainment would include enrichment technologies [1]

⇒ Determined proliferant state could withstand political pressure, economic sanctions [14]

Proliferation of a Single Nuclear Device

⇒ More likely to be an end-goal for non-state actors

⇒ For a gun-type weapon, would only require 12kg of HEU, or 4kg of WGP [15], tamper, and a propellant [15]

⇒ Sufficient fissile material is likely already available through covert means: Russia has a 125ton uncertainty on its HEU stockpile

> "What instrument would you use to detect an atomic bomb hidden somewhere in a city?" "A screwdriver"
>
> *Oppenheimer [16]*

Problems with Current Export Controls: The Weakest Link

⇒ A.Q. Khan and Asher Karni showed that dense supplier schemes can and will be used by a proliferant, allowing exploitation of the *weakest link* in nuclear security

⇒ Many countries have weak nuclear security or no intention on complying on nuclear security

Weak Countries

⇒ Of the 84 key states (including weapons and transit states), only five of them scored higher than 50% on export control compliance of UNSCR 1540 [3]

⇒ The average compliance was below 25% for all states, multiple scored no compliance

⇒ Of the 30 states analyzed by Stinnett, 9 states had a score less than 50AU for implementation, and 11 states had a score less than 50AU for institutions [4]

Problems with Current Export Controls: Common Use

Computing

⇒ Many were surpised to find that the Playstation 2 was export controlled [17]

⇒ Super computing resources may indicate advanced nuclear arsenal production

⇒ MCNP was cited by entities without licenses $\sim 100\times$ in the past year [18]

Machining

⇒ Famously, Malaysia was able to produce many dual use parts under the A.Q. Khan proliferation network, despite having no nuclear capability

⇒ CNC and other precision technology increasingly available through commercial and civilian channels

⇒ "Moore's Law" for technology leads to continual price drops

Nuclear Related Technology

⇒ Neutron generators increasingly used for non-destructive analysis or interdiction*

⇒ Isotopes increasingly used for oil well logging

⇒ "Proliferation" of reactors and reactor grade materials (Zirconium, HEU for research reactors) are being encouraged by the IAEA and NPT [19]

Problems with Current Export Controls: (C)overt Proliferation

Overt Proliferation

⇒ No country seeking overt proliferation has been stopped (publically)

→ North Korea has resisted regulations

→ Israel is not an NPT signatory

⇒ Policy for deterrance of proliferation among determined and overt proliferants is still wanting

Covert Proliferation

⇒ Several countries have benefitted from covert proliferation

→ Soviet Union's first device is reportedly a copy of an American design [1]

→ India, Pakistan, South Africa all surprised the international community with tests

⇒ Covert proliferation requires interdiction to stop it, which is a complicated problem for fissile material [20]

⇒ Interdiction of dual-use goods is exceedingly difficult because of their diverse and inoccuous nature

Problems with Current Export Controls: Factor of Safety

⇒ Certain items are only possible for dual use if they are of a minimum specification

⇒ These specifications will likely have been created with a factor of safety in their originating document

⇒ A determined proliferant could absorb the economic and possible safety ramifications of not meeting factor of safety

⇒ Originating engineers or those well versed in the technology would be required to adjust the specifications

Some Items Controlled by Minimum Specification [1]

⇒ CNC Mills

⇒ Dimensional Inspection Systems

⇒ Furnaces

⇒ Isostaic Presses

⇒ Centrifugal balancing machines

⇒ Lasers

⇒ Superconducting Magnets (REBCO?)

⇒ Power Supplies

International and State Export Control Comparison: Legislation versus Capacity

> "[S]tates have made better progress in establishing the legal basis for their export control systems than they have in institutionalizing or implementing them."
>
> *Stinnett, et Al. [4]*

Legislation

⇒ The majority of public effort on nonproliferation relates to policy

⇒ Many states have established a good legal basis for nonproliferation and export control

⇒ Stinnett found the average score for the legal basis to be 68.2AU and the institutional mean score to be 58.4AU [4]

Capacity

⇒ Stinnett's metric has a mean score of 50.5AU on implementation of export controls [4]

⇒ Crail's metric grades a 23.5% fulfillment by the 84 key states [3]

⇒ Turkey and South Africa are particularly cited

International and State Export Control Comparison: Regulation versus Deregulation

> "...potential benefits from any peaceful applications of nuclear explosions will be made available to non-nuclear-weapon States Party to the Treaty on a non-discriminatory basis"
>
> *NPT [19]*

Regulation

⇒ Export controls are administered **discriminately** [21] [2]

⇒ Possibly current administration [6]

Free Trade

⇒ More (weapons) technology is developed by commercial interests than previously

⇒ Regulation is a deterrant to research for commercial interests

⇒ Previous administration favored this stance [6]

International and State Export Control Comparison: Convoluted Regulations

> "(In America) the law-maker has adopted numerous regulations that paid little attention to the distinction between low-tech and widely available items and advanced proprietary technologies, which led to the creation of a system of export controls characterised as 'fundamentally broken' as well as 'too rigorous, insufficiently rigorous, cumbersome, obsolete, inefficient, or any combination of these'."
>
> *Alavi, et Al. [6]*

⇒ Is convoluted regulation a deterrent to trade?

⇒ Open dialogue question

International and State Export Control Comparison: EU Internal/External Trade

⇒ The EU provides an interesting case study for international versus internal trade agreements

⇒ Up to 10% of EU trade is dual use goods

⇒ *Aime Richardt* case indicates why each sovereign state must be able to stop dual use export [6]

Internal Trade

⇒ Many sovereign states and now, with additions, some insecure states

⇒ New agreements now allow for internal trade without licensing, but each sovereign state is liable to uphold UNSCR 1540

⇒ Cast as trade measures instead of national policy/security measures

External Trade

⇒ A country indicated under the CGEA can receive dual use items

⇒ A registered customer in an NGEA country can receive specified dual use goods

⇒ A registered customer in a GEA country can receive limited dual use goods

⇒ Other, ad hoc licenses have been granted [6]

International and State Export Control Comparison: Re-Export and Free Trade Zones

Re-export

⇒ Case Study: Asher Karni [21]

→ Attempted to buy triggered spark gaps (used in lithotripsy *or* device assembly)

→ Supplier was PerkinElmer

→ Used a cover entity in Pakistan, South Africa, UAE, and the United States

→ Was stopped when an anonymous tipster lead to a rejected license

Free Trade Zones

⇒ Many countries offer Free Trade Zones, where tariffs and other restrictions are lightened

⇒ Ostensibly, these zones offer economic incentive for commercial interests coming to that country

⇒ UAE's Free Trade zones are particularly concerning, for their promised "confidentiality" and their government's refusal to cooperate on Asher Karni's prosecution

Conclusion: Nonproliferation is an unsolved problem

⇒ Many attribute *The Long Peace* [9] to the advent of nuclear weapons, however the increasing number of nuclear weapons states makes that peace more precarious

⇒ Nonproliferation in general has a checkered history, with questionable efficacy of any of its tenets

⇒ Export control, proper intelligence, and licensing for dual use goods are one arm of nonproliferation that can make a large impact

⇒ There are some policy, implementation, and institutional issues within the field of dual use export control that must be solved as soon as possible

Questions

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[2] United States Office of Technology Assessment. Export Controls and Nonproliferation Policy. Technical report, U.S. Government Printing Office, Washington, D.C., 1994.

[3] Peter Crail. Implementing UN Security Council Resolution 1540. *The Nonproliferation Review*, 13(2):355–399, jul 2006.

[4] Douglas M. Stinnett, Bryan R. Early, Cale Horne, and Johannes Karreth. Complying by Denying: Explaining Why States Develop Nonproliferation Export Controls. *International Studies Perspectives*, 12(3):308–326, aug 2011.

[5] Jason Harris. Personal Correspondence on Dual Use Export Controls for Nuclear Nonproliferation, 2017.

[6] Hamed Alavi and Tatsiana Khamichonak. EU and US Export Control Regimes for Dual Use Goods: an Overview of Existing Frameworks. *Romanian Journal of European Affairs*, 17(1), 2017.

[7] Dan Carlin. The Dyer Outlook, 2009.

[8] Kai Bird and Martin J. Sherwin. *American Prometheus: The Triumph and Tragedy of J. Robert Oppenheimer*. Alfred A. Knopf, 2005.

[9] Dan Carlin. The Destroyer of Worlds, 2017.

[10] Matthew Bunn. A Peril and a Promise: Nuclear Challenges Facing the Next U.S. President. In *Proceedings of the Winter Meeting of the American Nuclear Society*, Las Vegas, NV, 2016. American Nuclear Society.

[11] National Academy of Engineering. Grand Challenges - Engineering Challenges, 2012.

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[14] Scott Nicholas Romaniuk. Managing Proliferation: National, Regional, and Global Security in the New Age of Nuclear Weapons. *Terrorism and Political Violence*, 29(1):185–194, jan 2017.

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[17] David E Sanger. Letting the Chips Fall Where They May, jun 1999.

[18] T. Basaglia, Z. W. Bell, A. Burger, P. V. Dressendorfer, and M. G. Pia. Ghost Science. In *Proceedings of the IEEE Nuclear Science Symposium*, Atlanta, GA, 2017. IEEE.

[19] United Nations. Treaty on the Non-Proliferation of Nuclear Weapons, 1968.

[20] IAEA Incident and Trafficking Database 2016 Fact Sheet. Technical report, International Atomic Energy Agency, Vienna, Austria, 2016.

[21] Bryan R. Early. Explaining Nonproliferation Export Controls, 2009.