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# Export control and nuclear safeguards

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***Abstract:***

*The control of strategic trade has been set up progressively in the past five decades as a barrier against the diffusion of sensitive materials, components and technologies, which could be used for the proliferation of nuclear, biological and chemical weapons of mass destruction and their means of delivery.*

*The result has been a continuously evolving multi-layered regime which comprises treaties, international agreements, UN Security Council Resolutions, embargo measures and national laws. In particular, nuclear export controls and international safeguards have developed in parallel in phases triggered by major international events, which showed that the insufficient scope of the controls existing at that time, as well as the legal framework's loopholes could be exploited to acquire sensitive goods. Although not implementing export controls, the IAEA benefits from their existence and from the inclusion of Model Additional Protocol's requirements related to its Annexes I and II that also provide background information for IAEA's verification activities.*

*The paper reviews the background and key aspects of strategic export controls, discussing their contents and relevance to countering the proliferation of weapons of mass destruction as well as the synergies with nuclear safeguards, describing challenges and open issues.*

**Keywords:** export control; nuclear safeguards; non-proliferation; dual-use; strategic trade

## 1. Strategic export control and nuclear safeguards

Strategic export control is a barrier against proliferation called for by United Nations Security Council Resolution 1540 [1], aiming to limit the unauthorized access to strategic technology and goods.

Export control and nuclear safeguards developed in parallel, as two intimately linked elements of the non-proliferation framework. This link is evident in both the Non Proliferation Treaty [2] and the Nuclear Suppliers Group (NSG) Trigger List guidelines [4]:

- The Non Proliferation Treaty's Art. III.2. subjects the export of nuclear items to international safeguards
- Safeguards are a condition of supply for nuclear goods also clearly stated by the Nuclear Suppliers Group's Trigger List guidelines [4, Art. 4].

### 1.1 The Non-Proliferation Treaty (NPT)

The close relationship between export control and nuclear safeguards is clearly visible in the NPT Article III.2's requirement for safeguards as a principal condition of the supply of nuclear items:

> *Each State Party to the Treaty undertakes not to provide: (a) source or special fissionable material, or (b) equipment or material especially designed or prepared for the processing, use or production of special fissionable material, to any non-nuclear-weapon State for peaceful purposes, unless the source or special fissionable material shall be subject to the safeguards required by this Article.*

The need to interpret the term "especially designed or prepared for" components led to the formation of the NPT Exporters' (or Zangger) Committee, which could not come up with a definition but instead identified a list of key nuclear fuel cycle items. The resulting "Trigger List" (i.e. a list of equipment and facilities "triggering" the need for safeguards) and guidelines for the supply were communicated to Member States by the IAEA in INFCIRC/209 latest revision is reported in [6].

### 1.2 The Nuclear Suppliers Group (NSG)

In line with the NPT provisions, many steps were undertaken for the development of international nuclear safeguards, with the objective of "*preventing diversion of nuclear energy from peaceful uses to nuclear weapons or other nuclear explosive devices. […] The safeguards […] shall be applied on all source or special fissionable material in all peaceful nuclear activities within the territory of such State, under its jurisdiction, or carried out under its control anywhere*." (NPT, art. III.1).

The effort led to the definition of a Comprehensive Safeguards Agreement (CSA – INFCIRC/153) defining how IAEA safeguards would be implemented in NPT States in compliance with the NPT Article III.1

The Indian "peaceful nuclear explosion", in 1974 showed that, notwithstanding the entry into force of the Non


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Proliferation Treaty, various countries had anyway exported nuclear technology to India, a non-signatory to the Treaty.

To address this gap, a group of nuclear supplier states decided to form the "Nuclear Suppliers Group (NSG)" [3] which, like the Zangger Committee, also issued additional Guidelines in 1978, published as INFCIRC/254/Part 1 and including an extended Trigger List [4].

The NSG has been quite active since its establishment, growing its membership to the current 48 Participating Governments, plus the European Commission as observer.

The results of its work are two distinct NSG guidelines, respectively the:

- "Guidelines for nuclear transfers" setting the conditions for transfers of nuclear items (i.a. nuclear safeguards and physical protection requirements) and containing two annexes, where Annex B contains the Trigger List (TL)
- "Guidelines for transfers of nuclear-related dual-use equipment, materials, software and related technology", containing in annex the Dual-Use List (DUL) [5]

The creation of the second set of guidelines covering dual-use equipment was decided in 1992, after the discovery of the covert Iraqi nuclear programme, supported also by the illicit import of non-Trigger List goods and technology.

## 2. International Safeguards framework

The discovery of undeclared proliferation activities in Iraq in 1991 was also a turning point for what concerns the international safeguards framework.

After having implemented Comprehensive Safeguards Agreements (CSA) with a focus on declared nuclear material at declared facilities for decades, the discovery of the Iraqi military nuclear programme in the 1990s led the IAEA and its Member States to start a paradigm shift for the implementation of NPT safeguards, from both a legal and practical point of view. From a legal point of view, the introduction in 1997 of the "Model Protocol Additional to the Agreement(s) between State(s) and the International Atomic Energy Agency for the Application of Safeguards" (AP - INFCIRC/540) [7] expanded the set of information the State transmits to the Agency under their reporting obligations and expanded the verification toolkit at the IAEA disposal to exclude the presence of possible undeclared nuclear material and activities in a State.

### 2.1 Model Additional Protocol

The Additional Protocol's Article 2.a. requires that States:

> *..... shall provide the Agency with a declaration containing:*
>
> *(i) A general description of and information specifying the location*
>
> *of nuclear fuel cycle-related research and development activities*
>
> *not involving nuclear material…*
>
> and
>
> …
>
> *(iv) A description of the scale of operations for each location engaged*
>
> *in the activities specified in Annex I to this Protocol.*

Annex I lists fifteen key nuclear fuel cycle related activities:

i. The manufacture of *centrifuge rotor tubes* or the assembly of *gas centrifuges*.
ii. The manufacture of *diffusion barriers*.
iii. The manufacture or assembly of *laser-based systems*.
iv. The manufacture or assembly of electromagnetic isotope separators.
v. The manufacture or assembly of *columns* or *extraction equipment*.
vi. The manufacture of aerodynamic separation nozzles or vortex tubes.
vii. The manufacture or assembly of uranium plasma generation systems.
viii. The manufacture of *zirconium tubes*.
ix. The manufacture or upgrading of *heavy water or deuterium*.
x. The manufacture of nuclear grade graphite.
xi. The manufacture of flasks for irradiated fuel.
xii. The manufacture of *reactor control rods*.
xiii. The manufacture of criticality safe tanks and vessels.
xiv. The manufacture of irradiated fuel element chopping machines.
xv. The construction of *hot cells*.

2.a.(i) allows the IAEA to identify those research activities which carry out potentially sensitive and relevant research, which could be transferred "intangibly" violating the export control provisions (Intangible Transfers of Technology). These R&D sites would not appear in the declarations under 2.a.(iv) because not linked to the actual presence of nuclear material and can therefore be captured by the requirement of 2.a.(i).

The AP also requires export declarations of "Trigger list" items (see above NSG) listed in its Annex II, related to nuclear activities listed in Annex I.

| Annex B item | Title | Since | Year |
|---|---|---|---|
| 1.8 | Nuclear reactor internals[1] | Rev. 3 | 1997 |
| 1.9 | Heat exchangers | Rev. 3 | 1997 |
| 1.10 | Neutron detectors | Rev. 3 | 1997 |
| 1.11 | External thermal shields | Rev. 12 | 2013 |
| 3.5 | Neutron measurement systems for process control | Rev. 12 | 2013 |
| 5.2.1.c | Solidification or liquefaction stations | Rev. 12 | 2013 |
| 5.2.3 | Special shut-off and control valves | Rev. 9 | 2007 |
| 6.8 | Complete heavy water upgrade systems or columns therefor | Rev. 3 | 1997 |
| 6.9 | $NH_3$ synthesis converters or synthesis units | Rev. 12 | 2013 |
| 7.1.9 | Especially designed or prepared systems for the conversion of $UO_2$ to $UCl_4$ | Rev. 4 | 2000 |

**Table 1:** Items part of the NSG Trigger List (Annex B of INFCIRC/254 Part 1, as of Revision 14 of 2019), which are not listed as such in Annex II of the Additional Protocol (INFCIRC/540c), with their year and revision of appearance in the Trigger List. The table does not contain items that have only been amended (e.g. code, title, text) in the Trigger List since 1995.

Art. 2.a.(ix) of the AP requires that States:

> *…shall provide the Agency with a declaration containing the following information regarding specified equipment and non-nuclear material listed in Annex II:*
>
> *For each export: the identity, quantity, location of intended use in the receiving State and date … of export;*
>
> *Upon specific request, confirmation as importing State of information provided by another State concerning the export of such equipment and material*

Annex II lists the items contained in the NSG Trigger List (INFCIRC 254/Part 1) available in 1995 (Rev. 2). Unfortunately, the AP Annex II list has not been amended thereafter, unlike the NSG TL, amended already several times (the current version being Rev. 14 of 2019). This fact creates discrepancies to exporters and authorities which is addressed in various practical ways as outlined in [8,9].

The States or other organizations depending on the countries' attribution of competences (e.g. EURATOM for some European Union Member States), are responsible for retrieving AP-related information and provide it to the IAEA along with the CSA-related and other required declarations. The experience of some ESARDA members with the activities and export declaration provisions of the AP is summarised in [10].

### 2.2 State Level [safeguards] Approaches

From a practical point of view, building on both CSAs and the AP, the current IAEA nuclear safeguards framework (the so-called State Level Concept –SLC) foresees the application of "State Level [safeguards] Approaches" (SLA), uniquely tailored to each State, with the objective to detect any NPT non-compliance, spanning from detection of diversion of declared nuclear material to the detection of undeclared nuclear activities at undeclared sites.

For the design and conception of a SLA (Figure 1), the IAEA evaluates all the possible routes to achieve weapons-useable material in a given State through the application of Acquisition Path Analysis (APA). In order to assess the plausibility of each proliferation path, the Agency evaluates its potential time to completion, which in turn depends, *inter alia*, on the State's technical and industrial capability.

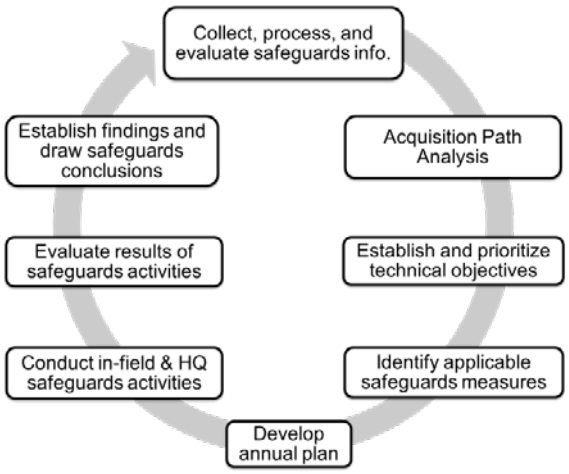


**Figure 1:** Flow chart of processes supporting State-level safeguards implementation, adapted from [11].

### 2.3 SLA Acquisition Path Analysis

An acquisition path is defined as a sequence of activities which a State could consider in order to acquire a Significant Quantity of weapons usable material. The APA is a key

[1] Only mentioned in the Explanatory Note to item 1.2 (Reactor pressure vessels) in Annex II of the Additional Protocol

element of the SLC. By considering the State's nuclear profile, the APA generates a list of acquisition paths ranked by their attractiveness for the State. The acquisition path analysis (APA) analyses all conceivable acquisition paths, retaining only those that could be completed within a short period, aiming to optimise the design of sets of safeguards measures focusing on the critical (more plausible) paths, while maintaining the desired efficiency and effectiveness standards. Currently, this process is mainly based on expert judgment. However, comprehensive guidance is available, since the IAEA's requirements state that APA must be objective, reproducible, transparent, standardized, documented and as a result non-discriminatory [12].

Within the APA, the information and insights coming from the export control regime and the trade analysis of dual-use and non-dual-use goods and equipment has the potential to play a very important role in understanding the technical and industrial capability of a State and the direction in which it is evolving. Together with all the other information and analyses performed by the IAEA, these insights enable a more effective acquisition pathway analysis and therefore a more efficient design of the SLA.

A central tool at the IAEA's disposal to support the identification and the characterization of acquisition paths in a State's nuclear fuel cycle is the Physical Model [13]. The Physical Model is a full description of the nuclear fuel cycle, internal to the IAEA's Department of Safeguards, subdivided into several volumes. It contains indicators (materials, equipment, technology, observables) of nuclear activities with different degrees of strength. Some material and equipment indicators are linked with explicit references in the text to controlled items and, through e.g. NSG Handbooks, to Harmonised System's customs codes.

Whereas the detection of exports of Trigger List items to a State where the nuclear activity using these items is not declared to the IAEA would clearly indicate covert nuclear activities, the export of dual-use items is more difficult to put in relation to undeclared activities. Nevertheless, the dual-use items contained in the Nuclear Suppliers Group's Guidelines are part of, and referenced in the IAEA's Physical Model. Tracing transactions based on customs commodities is one of the detection activities performed by IAEA as part of their verification process, and dedicated tools have been developed by the JRC to facilitate this [14].

## 3. Strategic Trade Control related sources of Information

The IAEA does not implement export controls, but benefits from their existence.

Besides the data formally due by States and collected during regular inspection activities, the IAEA makes wide use of various sources of information to detect potential indicators of undeclared nuclear material and activities, and for States with an AP in force, be able to derive broader conclusions on the absence of undeclared nuclear material and activities.

Apart from regular open-source information, these include trade data analysis, based on customs data, together with the analyses of actual and attempted covert procurement for nuclear-related goods (both single and dual-use) – information which is received from States and their companies on a voluntary basis [15]. Cross-matching the declarations with data sources used in verification may provide red flags that require further assessment.

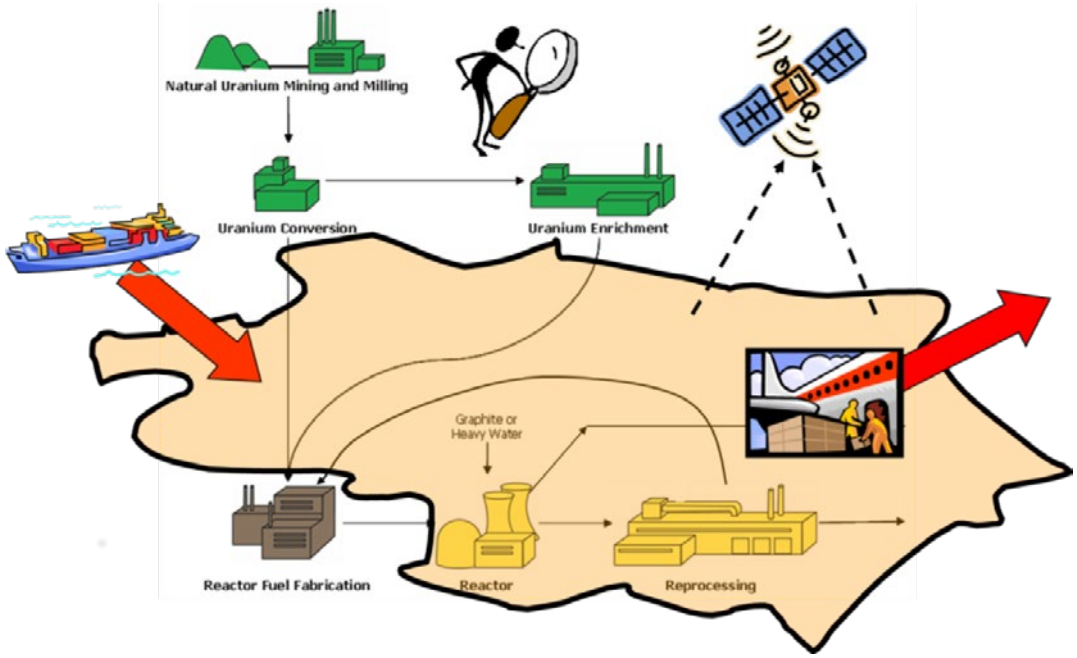


**Figure 2:** Matching State's declarations and verification activities

The strategic export control framework not only provides an important barrier to proliferation, it also helps generating data instrumental to the verification process. The following paragraphs describe some of the potential sources of information within the strategic export control framework.

### 3.1 Strategic Trade Data

For the analysis of strategic trade data, analysts can use international trade databases, which are provided by several web services; notably, under WTO rules, almost all States provide data on their imports and exports in thousands of commodities to UN Comtrade. Export-controlled items listed in regulatory documents represent a limited amount of the international trade volume covered by trade databases, which include all commodities.

As previously seen, Trigger List or dual-use items can be associated to specific parts of the nuclear fuel cycle. In order to acquire additional information on a State's nuclear-related trade, the selected items' Harmonized System codes can then be obtained, by which trade data can be retrieved from data providers [14].

The process is complicated by the fact that the commodities' categorisations used by licensing (e.g. the EU dual-use control list [16, 17]) and customs (Harmonized System) differ and the correlation between the two datasets is not one-to-one.

### 3.2 Denied export authorisations

Although the members of the regimes and the EU member states among them, exchange information about denied export authorisations, these are not directly available to the IAEA. The associated information may be relevant to verification activities, also for dual-use items not directly nuclear-related, including catch-all clauses on non-listed items.

### 3.3 Intangible Technology Transfers

Technology according to the NSG guidelines is the knowledge needed to perform an activity. Like items, components and materials, also software and technologies are subject to export authorisations and may be a proof of illicit transfers and undeclared activities. However, software and technology's export declarations are not included in AP's Annex II.

Although the availability of technology (and software to model, assist the processes) may be described in association to AP Annex I's list of activities, their transfer to third country's entities is therefore not due to be declared to IAEA. We have therefore an inconsistency and distortion with respect to the national export control systems and NSG guidelines.

In the Additional Protocols of the NWSs, there are however provisions to report to the IAEA nuclear fuel cycle-related research and development in cooperation with NNWSs [Ref: INFCIRC/263/Add.1, INFCIRC/288/Add.1, INFCIRC/290/Add.1, INFCIRC/327/Add.1, INFCIRC/369/Add.1, INFCIRC/754/Add.6] – which to some degree cover intangible technology transfers. Also, the model AP Article 2 a. (i) requires States to report NFC-related R & D, and these declarations often include R& D conducted in cooperation with entities in other States.

Linked to this, also the on-site provision of technical assistance and associated technology transfer is subject to national authorisation, although for the time being the EU export control framework still has it as a Joint action process separate from the dual-use export control requirements.

Technical assistance is also an activity performed by the IAEA itself through its Technical Cooperation programme, and can constitute an additional source of indicators for third countries.

## 4. Compliance and procurement outreach

The implementation of strategic trade controls and nuclear safeguards can be effective only relying on informed, aware, collaborative and complaint suppliers and exporters. For this reason also, the IAEA encourages suppliers to provide information on procurement attempts for nuclear-related (dual and single use) goods, what constitutes a valuable source of information to enable the early detection of potential undeclared nuclear activities.

Export compliance is a two way process and public authorities should promote an engaging and trusted relationship with the exporters that can be facilitated by an effective outreach strategy and open contacts and communication with the exporters. Industry can apply due diligence procedures and develop Internal Compliance Programmes (ICPs) as one of the most effective ways in addressing proliferation risks and ethical sensitivities, also besides those foreseen in the law.

The supply chain diversity presents threats and complexities. Nuclear exporters are willing to comply but challenges like the illustrative character of the TL may create interpretation issues. Some States interpret it as an indicative list while others consider that TL export controls only apply to the items specifically mentioned on the list.

More broadly, interpretation issues and "catch-all" controls relate not only to dual-use items originating from the Nuclear Suppliers Group, but also from all the international export control regimes [18,19,20,21], included for the EU in the dual-use control list published every year as Delegated Act [16], amendment to the EU Dual-use Regulation's Annex I [17], and adopted also by several non-EU countries.

Governments should strive to apply controls consistently without interfering with legitimate business or distort competition. This needs to take into account complex supply chains involving several actors (suppliers, clients, brokers, shippers, sub-contractors, banks, research, consultancy and others).

Certain emerging technologies may also provide opportunities with regards to export compliance. Modern approaches like Distributed Ledger and Blockchain could facilitate the logistics and document access all along the supply chain thus improving the processes and speeding up shipments across the controls [22].

Increased and smarter awareness is a key to a successful control of possible sensitive transfers, avoiding also to unduly hinder research and development, as well as legitimate trade.

## 5. Conclusions

The paper revisited the parallel evolution of international nuclear safeguards and export controls, underscoring once more their close and complementary relationship, which should be continuously reinforced in order to more efficiently counter nuclear proliferation in violation of the NPT.

The various components of the safeguards and export control framework all contribute to the prevention and verification of the absence of undeclared nuclear activities potentially aiming at the development of nuclear weapons and means of delivery.

Various declarations are due to IAEA and EURATOM, and sources of independent information can help identifying anomalies and inconsistencies, whenever made available.

In the framework of the Additional Protocol (AP), information is exchanged with the IAEA about real exports of nuclear technology. Additionally the IAEA has arrangements with some States to exchange information about refused export control licenses. This provides the IAEA with the possibility to detect at an earlier stage illicit trafficking networks. However, monitoring technology transfers by intangible means poses its own set of problems.

Countries with an Additional Protocol in force are inherently more safeguarded and thus having an AP in force minimizes proliferation risk, making positive export licensing decisions easier to make. The existence of an AP is also a key instrument for the IAEA to use to derive State Level conclusions.

The reporting requirements to IAEA do not cover supply of Trigger List technology, as there are no physical exports, nor customs declarations to complete. States may anyway report also such transfers, where they are known, on a voluntary basis.

The role of suppliers and exporters is crucial to the success of the system, at the same time safeguarding legitimate trading activities from unnecessary burden and delays. Collaboration and exchanges with suppliers is key to defining complete and workable guidelines and procedures.

The ESARDA Export Control Working Group – bringing together various stakeholders, including representatives of larger nuclear industries, authorities, universities, research institutes and NGOs – provides a multi-disciplinary open forum to exchange views for the potential benefit of safeguards and export controls. Exchanges on this subject are also taking place with INMM, supported by discussions at symposia and joint meetings that could hopefully intensify further in the future.

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